GEOLOGICAL SURVEY OF CANADA.

ALFRED R. C. SELWYN, F.R.S., F.G.S., DIRECTOR.

REPORT OF PROGRESS

FOR

1873-74.

Montreal.
DAWSON BROTHERS.
1874.

Presented to

Prof J. D. Whitney Cambridge Mass

By the Director of the

GEOLOGICAL SURVEY,

In behalf of the Government of the Dominion of Canada.

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AND
MONTREAL

TABLE OF CONTENTS.

I.

II.

III.

IV.

V.

VI.

VII.

VIII.

IX.

X.

MAPS AND ILLUSTRATIONS ACCOMPANYING THIS REPORT.

NOTE.—Some of the Maps mentioned in this Volume have not been published, but are kept for reference in the Geological Survey Office.

ERRATA.

Page 7 Foot-note, line 5 from top, *for* 285.60 *read* 347.08.

37 Lines 2 and 22 from top, and side-notes, *for* Vermillion *read* Vermilion.

48 Line 8 from bottom, *for* peices *read* pieces.

58 Line 23 from top, *for* Artic *read* Arctic.

63 Analysis 1, line 3, *for* 42.25 *read* 48.25 ; and analysis 2, line 3, *for* 53.26 *read* 53.36.

64 Analysis 5, line 4, *for* 9.66 *read* 9.96, and in the analysis of soap-clay, line 1, *for* 36.48 *read* 36.49.

78 Line 19 from bottom, *for* gives *read* gives 41.49.

83 Line 6 from top, *for* Assnineboine *read* Assineboine.

84 Line 5 from top, *for* from and *read* and from.

101 Line 11 from top, *for* for progress *read* progress for.

103 Line 11 from bottom, *for* baryta *read* barytes.

108 Line 15 from top, *for* granite *read* slightly garnetiferous.

128 An error occurs here in the paging, but none of the Report is left out.

148 Line 20 from bottom, *for* 158 *read* 160.

155 The sum of the first section should be 13 feet instead of 23.

156 The sum of the last section should be 31 feet 5 inches instead of 31 feet.

180 Foot-note, second line, *for* magnetize *read* magnetite.

197 Line 15 from bottom, *for* incidently *read* incidentally.

224 Second analysis, line 3, *for* 0.32 *read* 0.33.

226 For 58.80, 57.60 and 68.83, the amounts of metallic iron in analyses II, VI, and X, *read respectively* 59.87, 57.57 and 68.33.

237 In the table of analyses of bog ores transpose 54.46 and 40.00, the metallic iron in III and IV.

239 *For* 48.80, the metallic iron in analysis III, *read* 42.71.

241 The metallic iron in analysis II should be 36.34 instead of 37.53 as given in Mr. Dawson's report.

NOTE.—Besides the above a number of other typographical errors occur, but are not of sufficient importance to be included in this list.

GEOLOGICAL SURVEY OF CANADA.

REPORTS

OF

EXPLORATION AND SURVEYS,

1873-74

GEOLOGICAL SURVEY OF CANADA.

MONTREAL, May, 1874.

SIR,—I have the honor to transmit, for the information of His Excellency the Governor General in Council, the accompanying Reports relating to the Surveys and Investigations of the Geological Corps during the season of 1873-74.

I have the honor to be,

Sir,

Your Obedient Servant,

ALFRED R. C. SELWYN,

Director of the Geological Survey.

To

The Honorable DAVID LAIRD, M. P.,

Minister of the Interior,

OTTAWA.

SUMMARY REPORT

OF

GEOLOGICAL INVESTIGATIONS,

BY

ALFRED R. C. SELWYN F.R.S., F.G.S.

ADDRESSED TO

THE HONORABLE DAVID LAIRD, M.P.

MINISTER OF THE INTERIOR.

SIR,—Respecting the investigations of the Geological Survey during the past season, 1873–74, I have the honor to report, for the information of his Excellency the Governor-General in Council, that, through the commendable energy and diligence of the various members of the corps under my direction, very satisfactory progress has been made, and a number of new and important facts have been ascertained in connection with the structural geology and also relating to the mineral resources of the Dominion; while much valuable topographical work has likewise been accomplished. Some of the facts referred to are detailed in the various Reports which are now submitted, while the particulars of others, which seem to require further investigation and study, are deferred to a future occasion.

Progress of Exploration and survey.

Besides special examinations and surveys in the field, of short duration, made by Dr. Harrington, Mr. Robert Barlow and Mr. Weston, the work of general exploration has been carried out as nearly as possible in accordance with the scheme submitted to the Hon. the Secretary of State for the Provinces with my letter of the 9th April, 1873. (See Appendix.)

Services of Sir W. E. Logan.

Before proceeding, however, to notice further the labours of myself and colleagues, I wish to take this opportunity of recording my appreciation of the valuable gratuitous services which Sir W. E. Logan continues to give to the cause of Canadian Geology, as well as to the interests and objects of the Dominion Geological Survey, especially in the prosecution of the arduous task of unravelling the intricate details of the geological structure and the true stratigraphical sequence of the Lower Palæozoic rocks in Eastern Canada, upon the previous interpretation of which, through the abours of the Canadian Geological Survey, then under his direction, con-

siderable doubt and uncertainty has been thrown by recent articles, in Silliman's American Journal of Science and elsewhere, from the pen of Dr. T. Sterry Hunt, whose earlier views on this question, as set forth in his many valuable and well known reports and papers, appear to have undergone an almost entire revolution, based, so far as I can understand, chiefly, if not entirely, on the evidence afforded by examination, comparison and study of specimens of rocks from Canada and from other widely separated regions, in connection with their general similarity in mineralogical characteristics, geographical position and other physical features. Whether the relative ages of great masses of crumpled and metamorphic strata can be thus determined apart from, or in the absence of palæontological and stratigraphical evidence, is a question which, as a stratigraphist of thirty years experience, I should decidedly answer in the negative. The degree and character of the metamorphism and mineralization which a group of strata exhibit, can not be relied on as certainly indicative of geological antiquity, and, as tending to strengthen this opinion, the recent researches of Mr. Richardson in British Columbia have shown that epidotic, chloritic and serpentinous rocks, with crystalline limestones and magnetites, are as characteristic of upper palæozoic, and perhaps also of even later formations where they have been subjected to an equal amount of plication and folding, as they are of the oldest palæozoic and protozoic strata, such as those of Eastern Canada and the New England States.

Views of Dr. T. Sterry Hunt.

Crystalline rocks in British Columbia.

The point under discussion, to the elucidation of which Sir W. E. Logan, as above stated, is devoting his personal skill and great experience, may to some apppear to be one not of sufficient importance to warrant the arduous labour required for its satisfactory solution. But, in as much as the correct interpretation and delineation of the geological structure of a large portion of Eastern America is involved in its determination, I have considered it desirable that the attention of the Survey should be directed to it; and accordingly Mr. Arthur Webster of the Geological Corps has been deputed to assist Sir William Logan, especially in making the requisite topographical measurements, and he has been so employed during the past season, and has accomplished a large amount of very excellent work, which besides serving the special purpose for which it has been undertaken, will likewise be exceedingly valuable in the construction of an accurate topographical map of the region. And I am now able to state on behalf of Sir William Logan that a full report of the result of the investigations will be given, when the necessary examinations have been completed.

Valuable assistance from Principal Dawson.

To Principal Dawson the Geological Survey is likewise largely indebted for his most valuable assistance in connection with the examination and description of the fossil plants collected by the labors of the survey in British Columbia and other portions of the Dominion, and also for his very

valuable illustrated report on the fossil flora of the Canadian Lower Carboniferous and Millstone Grit formations. It was mentioned in my summary report of progress presented in May, 1873, that this report was then being prepared, and would be issued shortly, and I may now state that it was printed and published during the past autumn, and forms a very valuable addition to the literature of Canadian palœo-phytology. 200 copies of it have been distributed in Canada and Great Britain and on the continent of Europe.

Labours of Mr. Selwyn

My own work during the past summer has consisted in making a preliminary examination of that portion of the North West Territories of the Dominion extending westward from Fort Garry to Rocky Mountain House on the upper North Saskatchewan River. A brief account of the observations made during the journey formed the subject of a paper read in January last before the Natural History Society of Montreal. This has since been published in the Canadian Naturalist, Vol. vii, No. 4, and a fuller and more detailed Report is submitted herewith.

Diamond-pointed steam drill

With a view of hastening and facilitating the geological exploration of the North West territory especially in connection with the determination of facts relating to water supply and the occurrence of available beds of coal and other useful minerals in proximity to the proposed course of the Canadian Pacific railway, it was thought advisable to commence a series of borings to be extended across the plains from Fort Garry westward. And accordingly the purchase of a diamond-pointed steam drill, similar to the one in use in New Brunswick, was sanctioned last spring by the Government in accordance with my recommendation (See Appendix); one half of the requisite expenditure to be born by the Pacific railway-survey fund. The machine, however, which had to be purchased in New York, did not reach Fort Garry till the first week in August; and partly owing to the late period of the year at which operations could be commenced, and from the want of proper tools for penetrating the great thickness of loose superficial deposits, as well as the requisite piping to support the sides of the hole, delays occurred which together with the early setting in of winter combined to render the season's operations far less successful than could have been desired. In prosecuting this work during the ensuing summer a different system will be adopted which, from the knowledge acquired last year respecting the general character of the country to be explored and the difficulties to be encountered, I have every reason to believe will produce satisfactory results. The boring operations last year were in charge of Mr. Waud, M.E., assisted by Mr. Alexander McDonald, a skilful practical engineer, who had previously been employed by the Railroad department to conduct boring operations in New Brunswick and Nova Scotia. Of the borings made, the first, on the left bank of the Assineboine

Boring operations in Manitoba.

near the military barracks, was carried to a depth of only 31 feet from the surface through silt and stiff blue clay, when a layer of gravel and boulders was encountered, through which it was found impossible to work with the diamond drill. The second on the south-west border of Shoal Lake lot 31, range II., township 15, was carried to a depth of 54 feet through clay and marl with imbedded boulders, when, owing to the sides falling in, it had to be abandoned. The third was commenced on the 16th of October at Rat Creek, 60 miles west of Fort Garry, and was carried to a depth of 70 feet through silt and stiff blue clay when the severity of the weather stopped operations.

Report of Mr. Waud.

The details of the work and the difficulties encountered are stated in Mr. Waud's report. (Appendix II.)

Exploration of Mr. George Dawson and Mr Bell.

Simultaneous with my own explorations on the North Saskatchewan, other portions of this great western region were being explored by Mr. George Dawson along the forty-ninth parallel, in connection with the British American Boundary Survey,* and by Mr. R. Bell, of the Geological corps, along the valley of the Qu'Appelle River westward to the elbow of the South Saskatchewan. Mr. Bell's report is submitted herewith and the result of Mr. Dawson's observations will probably be incorporated in the reports of the Boundary Survey. This survey I am informed it is expected will be completed during the ensuing summer.

Since my return to Montreal on the 12th of November, the usual official duties connected with the superintendence of the work of the Survey and Museum, the preparation of reports, maps, &c., connected with the season's explorations; and attending to the printing and publishing of the volume of Reports lately issued, for 1872-73, consisting of 300 pages of letter press with maps and plates, has fully occupied my time and attention.

Geological Museum.

In the Museum the re-arranging, re-labelling, numbering and cataloguing the collections is making satisfactory progress. When completed it is proposed to issue a descriptive catalogue which it is thought will tend materially to enhance the value of the collections both for educational purposes and for the general information of the public. Considering the size and population of Montreal, the comparatively few persons who visit the Museum, only 1000 during the past twelve months, is certainly somewhat remarkable. I believe this arises, however, in a great measure, from the fact that the character and interest of the collection is not generally known. The doors are now open gratuitously to the public every day in the week, Sundays excepted, from 10 a.m. to 4 p.m.; and

Number of Visitors.

* The first part of Mr. Dawson's Report has been published since the above was written, and is a very interesting and valuable report on 'The Tertiary Lignite Formation in the vicinity of the forty-ninth parallel.

there are in the cases upwards of seven thousand named specimens of Canadian Fossils, Minerals and Rocks, illustrative of the economic and scientific geology of the Dominion.

In the library, which already contains upwards of 2000 volumes, comprising standard works of reference on Geology, Mineralogy, Metallurgy, Chemistry and Natural History, important additions are annually made both by purchase and presentation. The latter comprising valuable reports and maps issued by State Geological Surveys in America, Europe, India and Australia, as well as copies of the transactions of various scientific societies sent in return for the publications of the Canadian Survey. Like the Museum, the library is available to the public for purposes of reference and study. Want of space, however, at present is a serious drawback to the realization of its full value, and also prevents the proper arrangement of the books, the numbering and cataloguing of which is now in progress. Library.

Mr. E. Billings, who has charge of the Palæontological branch of the Survey and Museum, reports that in addition to his duties as Curator, he has been engaged in studying and describing fossils from Gaspé and from various localities in Nova Scotia and in Ontario. Some of the results of these investigations are given in Part I, Vol. II, of the Palœozoic fossils of Canada, which is now in the press and will be issued shortly. It will contain about fifty wood cuts and six lithographed plates of fossils with 125 pages of descriptive text. Palæontological branch.

Considerable additions have been made during the year to the palæontological collections. Among these there are many new species and three or four new genera, and the result of the season's collecting must be regarded as highly satisfactory. The principal collections are as follows: Collections.

1. Presented by Mr. A. Hill,	Carboniferous plants,	Sydney, C.B	51
2. Purchased from Mr. De Cew,	Devonian	Ontario	1905
3. Collected by Mr. Weston,	Silurian	Arisaig	450
" " "	Devonian,	York River, Gaspé.	200
" " "	"	Gaspé limestone.....	150
4. " by Mr. Foord,	"	Percé	220
5. Presented by Major Grant,	Silurian,	Hamilton, Ontario.	150
6. Collected by Mr. Robb,	Carboniferous plants,	Cape Breton	65
7. " by Mr. Waud	Silurian,	Manitoba	19
8. " by Mr. Selwyn	Silurian and Devonian,	Manitoba	22
9. " by Mr. Bell,	Cretaceous,	Qu'Appelle Valley.	20
10. " by Mr. McOuat,	Silurian,	Wentworth, N.S...	300
11. " by Mr. Richardson,	Cretaceous,	British Columbia...	350
			3871

Besides the above, a number of specimens of the fossil plant remains, associated with the great coal and lignite bearing formations of the Western plains have been collected; as also others from the coal-bearing formations of British Columbia. Microscopic sections of these have been pre- Microscopic sections.

pared by Mr. Weston and submitted to Dr. Dawson for examination and study, and the result of his observations is given pages 47, 48, 75, 78 and 81 of the accompanying Reports.

Drawings and lithographs by Mr. Foord.

Mr. A. H. Foord, the artist to the Survey, has done a large amount of very excellent work in the preparation of drawings and lithographs of fossils to illustrate the geological reports, and for the second volume of the Palæozoic Fossils of Canada. Amongst these may be mentioned four plates, drawn and lithographed, containing fifty-four figures of Palæozoic fossils; thirty drawings of Cretaceous fossils from British Columbia, some of large size and occupying considerable time. Also the preparation of the drawings and lithographs for the plates, containing twelve figures, which accompanies Appendix I. of Mr. Richardson's Report in the volume of Reports of Progress for 1872-73, just published. During the month of August and a part of September Mr. Foord was engaged collecting fossils from the Devonian rocks at Percé, Gulf of St. Lawrence, required by Mr. Billings, to enable him to complete his description of the fossils of the formation.

Work of Mr. Weston.

In the early part of the summer Mr. Weston devoted some time, and with considerable success, to a careful search for fossils in the dark earthy limestones associated with the dolomites and serpentines in the Eastern Townships. He also secured there, and subsequently at Arisaig in Nova Scotia, a number of interesting and instructive photographs illustrating the geological structure of these districts. He has likewise during the year made a very large number of sections, mounted for microscopic examination, of rocks and fossils, as well as of recent and fossil woods from various parts of the Dominion. Amongst the latter may be mentioned twenty eight slices of the recent and fossil woods from British Columbia, and thirty-four slices of lignites and plant remains from the North West Territories. The state of preservation of most of the plant remains from these Western coal formations makes it impossible to determine their characters without this method of examination.

Work of the chemical laboratory.

The chemical and mineralogical branches of the Survey, are now under the charge of Dr. B. J. Harrington, ably assisted by Mr. Christian Hoffmann. Respecting the investigations during the past year in these departments Dr. Harrington reports as follows:

The work in the laboratory, as in the previous year, has consisted largely in the examination of economic minerals; although a few rocks and minerals, more especially of scientific interest, have been analysed.

Assays of gold and silver ores.

Thirteen gold and silver assays have been made, including seven of samples from Marmora. Several samples from the quartz veins of Massawippi in the Eastern Townships have been assayed. The occurrence of alluvial gold in the district makes it probable that these quartz veins may prove to be auriferous, as yet, however, only traces of the precious metal

have been detected in the samples examined. It may be mentioned here that the average yield of gold deduced from twenty assays of samples from the Marmora Veins, made in the Geological Survey laboratory during the past two years is 1.6367 oz. per ton of 2,000 lbs. equal to $33.81 per ton. Of these twenty samples, twelve were from the Gatling Mines and gave an average of 1.9107 oz. to the ton, equal to $39.47. Gatling mines.

A yellowish decomposed vein stone brought by Mr. Richardson from Hope, in British Columbia, was assayed and gave at the rate of 271.48 oz. of silver to the ton of 2000 lbs. Besides the silver it contained lead, copper, iron, arsenic, antimony and sulphur. *

A specimen of native antimony brought by Mr. Semple to the Laboratory, stated to be from Garden River, Rupert's Land, was specially examined for silver but none found. Antimony.

Proximate analyses have been made of twenty-three samples of coal. Seven of these were from Vancouver Island and the results of their analyses have already been published in the Report of Progress for 1872-73. It has there been shown that although these coals have been spoken of by several writers as lignites, they possess all the character of true bituminous coals. Analyses of coals.

Six analyses of Cape Breton coals have also been made and the results published in the Report just mentioned. Six of the other coals analysed were from the Saskatchewan River between Edmonton and Rocky Mountain House. They are all brown coals, containing from 7½ to nearly 13 per cent of water; but for coals of their class are very good. The average composition deduced from the six analyses by slow coking is:

Water	10 34
Volatile Combustible Matter	29 90
Fixed Carbon	53 27
Ash	6 49

Nine complete and eight partial analyses of rocks and minerals of scientific interest have been made. Among the latter may be mentioned a new carbonate, occurring in the joints of a dyke near McGill College. This Analyses of rocks and minerals.

* This specimen was given to Mr. Richardson by Mr. Nelson M.P, and was taken from a heap of several tons of similar material from a claim on the same vein as the Eureka Mine mentioned page 66, Geological Survey, Report of Progress, 1871-1872, and where it is stated that a sample of the ore from the mines was found by Dr. Hunt to contain 1.19 per cent of silver. This is equal to 285.60 oz to the ton of 2,000 lbs. very nearly agreeing with the result obtained by Dr. Harrington. From the general geological features observed in portions of Central British Columbia, there is every reason to anticipate that a rich silver bearing region exists there, which only requires for its speedy development, the introduction of the capital, enterprise and skill which are certain to follow the opening up of direct communication with the East; but for the present want of which the silver veins, as well many of the other great natural resources of this portion of the Dominion, remain unproductive and neglected. A. R. C. S.

mineral was first noticed by Dr. Dawson and has accordingly being named *Dawsonite*. It is interesting on account of its containing over 30 per cent of alumina, probably in a state of combination with the carbonic acid·

Dawsonite.

Four mineral waters have been analysed, two qualitatively and two quantitatively. The quantitative analyses by Mr. Hoffmann were published in the Report of Progress 1872–73, Report of Mr. Robb, page 281. One of these waters from the Gowrie Mine, Cape Breton, contained large quantities of ferric sulphate, probably derived from the decomposition of pyrites in the coal. The corrosive action of water of this kind upon pumps often occasions much difficulty and necessitates lining them with wood.

Analyses of mineral water.

During the month of June considerable time was devoted to the investigation of the relations of some of the trap dykes which cut the palæozoic limestones in rear of the Montreal reservoir. Mr. William Dawson kindly assisted in surveying their courses and they have since been mapped to scale. They may be divided into trachytic and doleritic, or acidic and basic dykes, the trachytic being the older. The latter are probably all of the same age, but the doleritic ones belong to at least three different eruptions which have all taken place since that of the trachytic. Some of the minerals which they contain have been collected, among them, in addition to the normal constituents of the rocks, are, sodalite, dawsonite, fluorite, calcite, celestine, pyrite, pyrrhotite, quartz, mica, and a green mineral which is probably epidote.

Investigation and survey of trap dykes.

Later in the season, nearly all the iron mines which are being worked in the provinces of Ontario, Quebec and Nova Scotia were visited, as well as many which are not in active operation. Large collections of the ores were made and will be available for the Museum when sufficient space is obtained to display them. When properly arranged they will form an interesting series, as they were collected specially with the view of illustrating the mineral associations and characters of the Canadian iron ores.

Iron mines of Ontario, Quebec and Nova Scotia.

Dr. Harrington's report on the above named examination and on Canadian Iron Ores and their development is submitted herewith.

The labours during the past season of Mr. Richardson in British Columbia, of Mr. Vennor in Ontario, of Messrs McOuat and Barlow in Nova Scotia and of Mr. Robb in Cape Breton, are detailed in the respective reports of these gentlemen, which are submitted herewith. In all the localities named, observations and measurements have been made, whic form valuable and important contributions to our knowledge of the geology and the topography of the Dominion.

Exploration in Ontario, Nova Scotia and Cape Breton Island.

In New Brunswick, Professor Bailey and Mr. Ells have been engaged in perfecting the Geological map of the Grand Lake and Clones coal-fields, and of the adjacent older formations on the southern borders of the carboniferous area within the counties of Sunbury and Queens. For this

Labours of Professor Bailey and Mr. Ells in New Brunswick

purpose it has been necessary to perform a considerable amount of topographical work; 1150 miles of roads, streams and other features have been measured, chiefly by odometer, and carefully plotted on a scale of 100 chains to the inch; while the limits of the various formations have been traced out in greater detail and laid down on the map. When finished, which it is hoped it will be next season, the map cannot fail to be of great value geologically and otherwise. Already the chief superintendent of education in New Brunswick has applied for and been furnished with a tracing of it, to aid his officers in the adjustment of the boundaries of school districts. And the Commissioner of Works has made a similar application on behalf of the Board of Works and other local government departments, which has likewise been complied with. This map, a portion of which is now in the hands of the engraver, it is proposed to publish next year to accompany a complete report by Professor Bailey and Mr. Matthew upon the region which it will embrace. Completion of the geological map of Grand Lake and Clones coal fields.

I have the honor to be,

Sir,

Your obedient servant,

ALFRED R. C. SELWYN.

MONTREAL, MAY 1874.

"COPY."

APPENDIX.

MONTREAL, 9th APRIL, 1873.

SIR,—I have the honor to acknowledge the receipt of your letter of the 4th April, informing me that the Secretary of State for the Provinces wishes to be furnished with a detailed statement of the proposed operations of myself and the other members of the Geological Corps during the coming season, and that a discussion will probably take place shortly in the House of Commons upon the propriety of having a combined geographical and geological exploration of the Fertile Belt of the North West Territory made this year, and further requesting me to state whether such a survey is included in my proposed operations, also whether there are any fields of exploration not included in my proposed scheme of operations for the current year, but which I think it would be desirable, on public grounds, should be entered upon this season, and, if so, to specify:

1st. What these particular fields of Exploration are;

2nd. What funds are required to carry out such explorations as I would recommend; and,

3rd. Whether, in the event of the necessary funds being supplied, I could command the requisite staff to conduct the proposed operations.

In the annexed statement are given particulars which I think will be found to contain the information sought for in the above questions.

I have the honor to be,
Sir,
Your Obedient Servant,

(Signed,) ALFRED R. C. SELWYN.

E. A. MEREDITH, ESQ., LL.D.,
Under Secretary of State for the Provinces, Ottawa.

Proposed Operations of the Geological Survey.

1873.

Operations of the Survey for 1873.

1—SELF............Exploration in the Fertile Belt N.W. Territory.
2—MR. RICHARDSON..Coal Fields of British Columbia.
3—MR. R. BELL.....Exploration and Surveys in the Fertile Belt N.W. Territory.
4—MR. H. G. VENNOR..Surveys in Ontario: Iron, Gold and Phosphate deposits, tracing and mapping their distribution.

5—MR. MCOUAT.. ..Continuation of Survey of the Nova Scotia, Cumberland Co., Coal Fields.

6—MR. CHARLES ROBB..Surveys and Exploration Cape Breton Coal Field.

7—PROFESSOR BAILEY...Will continue the Exploration of the Coal formation of Central New Brunswick.

There are so many other localities within the Dominion where surveys would be desirable, and where important discoveries might result from them, that it becomes difficult to select any one or two as more especially claiming immediate attention on public grounds. At present, however, the survey fund does not admit of the further extension of operations; and, even if an additional amount were provided, the services of competent men could not be secured in time for the work of the approaching season. Localities where surveys are required.

In connection with the proposed examination of the Fertile Belt, and in view of making the examination in question as complete and effective as possible, I would suggest, for the consideration of the Minister, the necessity of the survey being provided with a diamond-pointed rock-boring apparatus. Examination of the Fertile Belt.

Where superficial deposits are so thick and wide-spread as they are in the region referred to, the knowledge which can be gained from surface examination alone of the nature and character of the deeper-seated strata is, at the best, limited, and, to a great extent conjectural, and unsatisfactory, whereas by the judicious employment of the diamond drill a number of highly important questions would be speedily and definitely determined. Amongst these may be mentioned the formation of artesian wells, the existence of springs of petroleum and of brine and also of deposits of rock salt and other valuable minerals, as well as the thickness and character of the coal seams.

I am at the present moment unable to give an estimate in detail of the amount which would be required for the purchase and working of the diamond rock-drill. The largest size drill, including the steam engine for working it, is adapted to bore to the depth of 1000 feet and costs $6000 American currency. For our purpose one of the smaller size would suffice, costing probably from three to four thousand dollars ($3000 to $4000.) Cost of diamond drill.

In the event of the proposal to purchase one of these drills being approved, and it being thought desirable to extend and hasten the exploration and survey in the North West Territory, a supplementary vote of $15,000 would, I think, be required, and would be expended in the purchase and working of the drill, and in payment of the services of two or three skilled topographical surveyors, who would relieve the geologists of all topographical work, and thus enable them to devote their whole time and attention to purely geological and scientific observations. Employment of topographers.

I may here state that Mr. Sandford Fleming, C.E., has informed me that the Pacific Railroad Company would probably undertake to pay one-half of any appropriation which may be made for the object of this examination.

If the work is to be commenced this season, immediate action in the matter would be requisite, and I should be glad to be advised as early as possible respecting it.

Petitions for surveys from Nova Scotia and Cape Breton

Petitions have been made for surveys in Pictou county, Nova Scotia, and in Victoria County, Cape Breton; besides these localities, I might mention, as requiring to be further explored and surveyed: the coal fields and the silver-bearing rocks of the Mainland of British Columbia; and the coal fields of Queen Charlotte Islands; the Otter Head Region, on the north shore of Lake Superior, where rich deposits of tin ore are said to have been recently discovered; the limestones of the Laurentian rocks in the region north of the Ottawa, and in other parts of the Province of Quebec; the great bands of mineral-bearing Huronian rocks which have been discovered between Lake Superior and Lake Winnipeg. And more immediately connected with researches, in structural, palæontological and theoretical geology, there are a number of districts which require minute and careful examination.

APPENDIX II.

REPORT

BY

Mr. W. B. Waud, M.E.,

OF OPERATIONS IN MANITOBA WITH THE DIAMOND-POINTED STEAM DRILL

1873.

Montreal, 31st December, 1873.

Sir,

Arrival at Winnipeg.

On the 5th August, Alexander McDonald, the engineer in charge arrived at Winnipeg by Red River steamboat with the Diamond Drill, a boiler with force pump and fittings, gearing for working the drill by horse-power, 400 feet of 2½in diar., tubular drill rods, 150 feet of 3" tubing (wrought iron,) annular and hollow boring heads with diamonds, and an independent steam pump with hose and other fittings.

Site of Bore-hole.

On arrival the above were conveyed to a spot selected for a boring on the bank of the river Assinneboine. The site chosen was a ledge of the north bank of the river 13 feet below the level of the adjoining prairie, and 12 feet above the level of the water in the river, on land the property of the Crown. On part of this property barracks for the accommodation

of the Militia have since been erected. The main object in boring here was to ascertain at what depth good water (a great desideratum in the town of Winnipeg and neighbourhood) could be procured, while a secondary object was to test the machinery before taking it into the country.

The interval between the 5th and the 14th of August with some interruptions from rain was spent in removing and fixing the machinery and making the sheers for raising and lowering the rods. On trying the engines we found that there was a considerable escape of steam between the face of one of the trunnions and that of the corresponding cylinder, the result of bad fitting on the part of the makers. **Fixing and testing Machinery.**

On the 14th Aug. we commenced boring with a screw augur 3″ dia'r., and 1'2″ in length, and worked with this tool a depth during the day of 25″. feet. At this juncture tho hole began to cave in, and after making and fitting up a ram we drove down a length, 18 feet of 3″ wrought iron tubing This tubing being driven, we bored with a screw augur 2½″ diar., and 1'2″ in length and on reaching a depth of 31 feet from the surface came upon a bed of gravel.

The strata passed through hitherto had been mud, silt and stiff blue clays, and the process of boring with the above augurs was necessarily slow, they having to be drawn and cleaned for every 14 inches gained in depth. **Strata penetrated.**

We here screwed on another length 13 feet of 3″ tubing and drove the whole down and thus secured the sides for a depth of 31 feet *i.e.* to the gravel.

The want of a valve augur here puzzled us, but we took one of the tubular drill rods, cut it, and got a chisel of steel welded on to it, and after chopping the gravel with it, got out the fragments by lowering the screw augur with mud on it to which the fragments stuck. We soon struck upon a hard stone, and the drill was set to work with an annular boring-head at the end of the rods. It, however, had not been long at work before a diamond was lost out of the boring-head. A fresh boring-head was put on, but no sooner had this been done than one of the iron rings or clamps round the end of the rubber steam-pipe broke off. From the time that the diamond drill was set to work, *i.e.* at the depth of 31 feet to the time that the hole was abandoned, *i. e.* at the depth of 37feet 9 inches, the drill never worked smoothly or satisfactorily. It jumped, and it was frequently brought to a standstill by obstructions in the hole, and it was evident that pieces were falling off the sides of the hole and getting under the boring-head, and the diamonds wore very badly. **Diamond lost**

During six working days, *i.e.* between August 16th and 25th, the drill had bored only 6 feet 9 inches, and this at a loss of one diamond and the wearing out of several others.

It appeared that we had struck upon a layer of boulders and gravel which

made it impossible to drive the 3″ tubing any lower so as to protect the boring head, and the hole was therefore abandoned.

Bore-hole abandoned.

I left the tubing, *i.e.*, 31 feet 1 inch of 3″ wrought iron pipe in the hole, so that, if thought advisable, the boring may be continued at a future date, though I think that, if operations are recommenced on this site, it will be necessary to start with a hole of larger diameter and to be provided with more than one size of tubing, so that after the largest size of tubing is driven down as far as possible, a smaller size may be put down within it, telescope fashion.

On abandoning this hole it devolved on me to decide as to whether another boring should be made in the vicinity It appeared to me that our outfit was anything but complete for going through the thick drift, which it is evident underlies the soil of the country round Winnipeg, and that to attempt another boring in that neighbourhood was only to court failure. I therefore determined on removal to "The Big Ridge," the second locality named in my instructions, hoping to find a different formation, and one more favorable for operating the drill.

Start for the "Big Ridge."

On the 28th August we started for the above-named neighborhood and reached "The Big Ridge" on the evening of the 30th. Here we camped and spent the two following days in reconnoitering the ridge in search of a site suitable for a boring.

This ridge is merely a rise in the ground, striking from north west to south-east, and forming a steppe, having an elevation of about 20 feet above the level of the prairie to the south of it. The absence of wood and water in sufficient quantities for our operations compelled us to go beyond this a considerable distance, and I eventually selected a site near a lake, covering an area of about 80 acres, and locally known as Lac de Laronde, in the S. E. quarter of section 31, range 2 W., Township 15. (See "Map of the Province of Manitoba.") We arrived at this place on the evening of the 2nd September.

Rate of travelling.

Our rate of travelling, our weights being heavy and being principally drawn by oxen, was necessarily very slow, our average speed on fair road being little more than 1½ miles per hour.

A day and a half were spent in fixing the machinery and in digging a trench from the lake for our water supply. The soil here is only 6 inches in thickness and the subsoil is an indurated clay and marl.

Our first step was to sink a hole with pick and shovel about 4 feet square. This hole we sank in two days to a depth of 12 feet and on the 8th of September, we commenced at the bottom of the hole to cut with a chisel percussively, raising and letting it fall by hand and getting the debris out with a valve auger. On the 9th of September, at a depth from the surface of 22 feet 6 inches we met with boulders embedded in the clay

and marl. The diamond drill was now set to work but had not been in operation long, before the walls of the hole began to give way.

We now put down two lengths, 25 feet of 3" wrought iron tubing.

In the interval between the 9th and the 15th of September, the drill was kept at work, occasionally interrupted by the sides of the hole below the tubing caving in, and during this time penetrated a distance of 31 feet 6 inches making the depth of the hole from the surface 45 feet. At this stage the caving in increased, and we came to the conclusion that we must have the hole tubed lower down, but the bottom of the tubing already in, rested on too hard ground to allow us to drive it any lower, and the hole below was caving in as fast as it was cleaned out. We therefore determined to sink the hole with pick and shovel till we reached the bottom of the tubing and put in 3½" tubing, drive it down as far as we could, and then, should the caving in continue, put down the smaller tubing within it. This second sinking was commenced on the 17th of September, and continued, with interruptions from rain, till the 25th, when a depth of 25 feet from the surface was reached, and several boulders through which the drill had penetrated were brought to light.

Difficulties from hole caving in.

Boulders bored through.

On the 27th September, at the bottom of this sinking we commenced cleaning out and enlarging the hole so as to admit of 3½" tubing.

The interval between the 27th September and the 6th October, was spent in enlarging the hole with the diamond rimer, but during this time a chapter of accidents occurred.

On the morning of the 29th September, a crack was discovered in the metal of the pump used for forcing water into the boiler, but was repaired by putting an iron clamp on and tightening it up with nuts.

This pump and the one mentioned below ought to have been provided with cocks to let out the water and thus prevent the formation of ice.

On the 30th September, a great part of the day was spent in putting two fresh diamonds into the rimer to replace those that were worn out.

On the 3rd of October the steam pump used for forcing water down inside the drill rods was found with a crack in it, and that and the next day were spent in repairing it. At this stage Mr. McDonald insisted on the impossibility of continuing the hole. I agreed with him as to the improbability of being able to do so with the tools at our command, and we therefore abandoned it.

I determined to go from here to Rat Creek with a view of boring there through the drift by hand, merely using the engine to assist in drawing and lowering the rods.

Departure for Rat Creek.

Having spent two days in packing and loading, we started on the morning of October 8th, and after a delay at the St. Laurent Settlement, arising from a temporary loss of our oxen, we arrived at Mr. Kenneth McKenzie's farm on the 14th.

On the 16th October we commenced boring with a 3¾· half-circle earth auger, about 6 feet in length. This we worked by hand, and during the day got down 25 feet and put in a length, 20 feet, of 3¼" wrought iron tubing.

Commence boring at Rat Creek.

On the 17th and 18th we bored respectively 25 feet and 20 feet, making a total distance from the surface of 70 feet.

On resuming work on the 20th, it was found that the hole had caved in considerably. This and the following day were spent in cleaning out the hole, but as the caving in continued we prepared to put in additional tubing. Three days were spent in making and fixing an apparatus for driving the tubing, and on the 27th October a length, 10 feet, was screwed on to that already in the hole, and the whole driven.

Strata penetrated.

The strata passed through in this boring so far are soil, silt, and stiff blue clay, the latter offering considerable resistance to the driving of the tubing. The top of the tubing, while being driven, had to be protected with babbit metal, and with this cap stood pretty well the blows of a heavy ram dropped from a considerable height. At this stage the severity of the weather put a stop to our operations, and having provided for the care, during the winter, of the various items entrusted to my charge, (full particulars as to the disposal of which will be found in my diary,) I brought our party down to Winnipeg.

I cannot but express my regret that the results which have attended our operations during our short campaign are so insignificant. The outfit necessary to transport machinery amounting to an aggregate weight of over six tons, has necessarily been somewhat costly. The machinery was not at my disposal till a late stage of the summer, *i. e.*, 5th of August. The deficiencies in equipment I supplied with such make-shifts as I could get made in the country.

I have the honor to be

Sir,

Your obedient Servant

W. B. WAUD.

A. R. C. Selwyn, Esq., F.R.S.

Director of the Geological Survey,

Montreal.

NOTE.—On examining the diamonds (black-carbons) which had worn out I found that these all shewed a finely cellular, or scoriaceous looking, structure and were apparently composed of minute grains, or diamond sand, imperfectly consolidated, while other stones which wore well were quite homogeneous and compact. It is evident that these cellular stones are easily disintegrated and broken by the rapid motion and percussion of the drill in contact with hard pebbles and boulders. A.R.C.S.

OBSERVATIONS

IN THE

NORTH WEST TERRITORY

ON A JOURNEY ACROSS THE PLAINS

FROM

FORT GARRY TO ROCKY MOUNTAIN HOUSE

RETURNING BY THE

SASKATCHEWAN RIVER & LAKE WINNIPEG,

BY

ALFRED R. C. SELWYN, F.R.S., F.G.S.

1873.

In view of prosecuting the geological exploration of the vast region lying between the Red River and the Rocky Mountains, to the accurate knowledge of which more than ordinary interest attaches at the present time in connection with the building of the Canada Pacific Railway, it was thought desirable to acquire from personal observation such information and general acquaintance with the coal deposits and other mineral and physical features of the region as would facilitate the future direction and superintendence of the work; and the journey to which the present report relates was undertaken last summer chiefly with this object in view, and also to ascertain at what points and in what manner the contemplated boring operations referred to, page 3, could be best carried out in reference to the determination of facts relating to the distribution of workable beds of coal and other useful minerals and to the procuring of fresh water over those portions of the country where the surface waters are for the most part of a saline character. Objects of the Expedition.

Before proceeding with the account of our expedition I would wish to record my appreciation of the valuable aid, and my sincere thanks for the kind hospitality afforded us by the gentlemen in charge of the several posts of the Hudson's Bay Company from Fort Garry to Rocky Mountain House and to which indeed are almost entirely due the comparative comfort and ease with which the journey was accomplished. Acknowledgment of assistance.

Leaving Montreal on the 7th July, I was joined at Toronto by Colonel W. D. Jarvis, Mr. Lewis Ord and Mr. Waud, and reached Fort Garry via Saint Paul, Ma., and Moorhead, on the 14th. Eleven days were occupied at Fort Garry, in making the necessary arrangements for the journey: purchasing horses, carts, equipments and supplies, and hiring men. Members of the party from Toronto.

These preliminaries having been satisfactorily completed we left Fort Garry, or Winnipeg, the capital of the province of Manitoba, situated at the confluence of the Assineboine and Red Rivers, latitude 49° 52′ north and longitude 96° 50′ west, on the afternoon of the 25th of July, and in fifty days, or on the 12th of September, I reached Rocky Mountain House, situated on the upper North Saskatchewan, latitude 54° 20′ north, and longitude 115° 10′ west. The total distance travelled, according to measurements which were made of the route by means of an odometer attached to the cart wheel, being 1056 miles.

Leave Fort Garry.

Distance travelled by land.

The return journey, occupying 44 days, was commenced on the 13th of September, and was performed entirely by water, via the North and Main Saskatchewan River and Lake Winnipeg, and thence by Red River to Fort Garry, which was reached on the 26th of October, the total distance being by river 995 miles and by lake 300 miles, extending through eighteen and a half degrees of longitude and four degrees of latitude. Stoppages and detentions from various causes amounted to eighteen days, we were therefore actually travelling for seventy-six days, and thus averaged for the whole journey nearly thirty-one miles per day, or on the land journey 26.4 miles per day and on the water journey 37 miles per day.

Distance travelled by water.

Although the speed with which the whole journey was performed did not afford time for accurate surveys or detailed examinations to be made, yet a number of facts were ascertained relating to the geographical and geological features of the region which will prove of great value in the prosecution of future explorations. A few photographic views were secured, but the majority of the plates which were exposed, from some unexplained cause—probably insufficient exposure—unfortunately showed no image when subsequently submitted to the developing process. A few interesting specimens were collected, but the most important fact ascertained was the occurrence on the North Saskatchewan River, between Edmonton and Rocky Mountain House, of a number of flat-lying workable seams of good coal; one of them measuring, in two exposures upwards of four miles apart, from eighteen to twenty feet in thickness, and very favourably situated for working.

Photographs.

Specimens.

Thick coal seams

On the westward journey by land no attempt was made to lay down the bearings and windings of the route; but on the river a continuous sketch survey was made from Rocky Mountain House to Cumberland and plotted on a scale of four miles to one inch. A reduction of this plan has been made to accompany the present report. It must be mentioned, however, that no measurements were made, and the distances given are entirely from careful estimation, based on the speed of our boat, the swiftness of the current, and the apparent length of each reach and bend.

Survey of the route.

From Fort Garry to Edmonton my party consisted of six persons besides myself:

Members of the party from Winnipeg westward.

Colonel D. A. Jarvis.
Edward Borron.
Lewis Ord.
John Lauder.
Joseph McDonald. } Scotch half-breeds.
Alexander Fisher. }

The two last named were selected as being thoroughly experienced voyageurs who were acquainted with the route and spoke English and French as well as the Chippeway and Cree Indian languages, and I may say that they proved to be not only experienced in all the arts of voyaging, but also active, intelligent, obliging and thoroughly reliable men. To the other members of the party my thanks are due for the hearty co-operation and emulation which they one and all evinced at all times in promoting the objects of the expedition, and by which they succeeded, often under adverse and trying circumstances, in making it both successful and agreeable.

Means of transport.

For the transport of the party together with their equipment and supplies, four Red River carts, one buck-board waggon and eleven horses, or Red River ponies were provided. Travelling with us from Fort Garry to Edmonton were two English gentlemen, Mr. Beresford Hope and Mr. Roberts, who intended crossing to the Pacific, and their two servants, so that our party consisted of eleven persons with a train of seven Red River carts, one buck-board waggon and sixteen horses. The horses were used as required, either for saddle or harness, while five or six of them were left to run loose, and as a rule each horse was not worked for more than half the day's journey, by which means, although we travelled almost every day for eight, nine or ten hours, all the horses had time enough to feed and rest, and sore backs, sore shoulders and knocked up horses, together with the delays and troubles so commonly resulting from these causes on a long journey, were entirely avoided, and after having travelled, in round numbers, 900 miles, and some of them more than 1,000 miles, in fifty days, the horses, carts and harness were sold at Edmonton for only $28.48 less than they cost at Fort Garry. On the sale of the carts and harness there was a gain of $6.72 and on that of the horses a loss of $35.20. From this it will be seen that carts, horses, etc., are as a rule more valuable on the Upper Saskatchewan than they are at Winnipeg.

GEOLOGICAL FEATURES.

As already mentioned, the rapidity with which we travelled left but little time for making surveys and minute investigations or for the collection of specimens; and such notes as I was able to make upon the geology of the country are the result of observations of the most hurried description, and cannot be expected to add materially to the information respecting it which has already been supplied, first by the labours of Dr. Hector in his admirable sketch of the geological structure of this region, published in the Journal of the Geological Society, (vol. XVII, 1861,) and which embraces the results of observations extending over a period of nearly four years, from 1857 to 1860; and secondly by those of Professor Hind, who also explored a large part of the eastern half of the area, or that which extends westward from Lakes Winnipeg and Manitoba to the 107th meridian, and whose observations were published in 1859 in an excellent and voluminous report with maps, sections and plates.

Dr. Hector's observations.

Professor Hind's observations.

From Fort Garry westward, on the route which we followed, no exposures of solid unmoved rocks were seen till within a few miles of Edmonton. For the whole of this distance—885.52 miles as measured by odometer—an universal mantle of drift and superficial deposits, sand, clay and gravel is spread over the face of the country, but gradually diminishes in thickness towards the higher levels or to the third prairie steppe, though even here, where the drift is often absent, the soft and friable nature of the subjacent Cretaceous formation gives rise to a deep rich soil, by which the bed rock is everywhere covered and concealed from view.

Prevalence of drift.

The entire region westward from Lake Winnipeg to the base of the Rocky Mountains has been described by Captain Palliser as "a plain gradually rising until it gains an altitude of 3,000 feet at the base of the mountain chain. The surface of the slope is marked by *steppes* by which successive and decided increases of elevation are effected, accompanied by important changes in the composition of the soil, and consequently in the character of the vegetation." The first prairie steppe, having an average breadth of 120 miles with a general altitude of not more than 700 or 800 feet above the sea, is apparently everywhere underlaid at no great depth by nearly horizontal strata of limestone and sandstone of Silurian and Devonian age; and the western limit of this steppe in British territory is marked by the long range of low hills extending from the Pembina Mountain northward to the Basquia Hills, and including the Riding, Duck and Porcupine Mountains.

Description of the region by Captain Palliser

First prairie steppe.

Dr. Hector, in describing this first prairie steppe, says, "To the most recent of these"—referring to the superficial deposits—"belong the

Dr. Hector's description.

low prairies which surround Lake Winnipeg and the lakes of that group, including the marshy country to the west of Manitoba Lake. In the vicinity of Red River Settlement its composition is of argillaceous marl with a deficiency of sandy matter, and it is invariably stratified in thin layers. Underlying this at various depths from the surface is a bed of stiff clay which forms the immediate margin of the river at many places. The upper layer of the deposit contains leaves and fragments of wood and reeds, and the whole is undoubtedly a fresh water deposit indicating a time when the Winnipeg group of lakes covered a much more extended area than at present. The surface of this deposit is about 75 to 100 feet above Lake Winnipeg, but it slopes gradually from the west, and at Pembina Mount, near St. Joseph, is at least 100 feet high. This ancient lake bottom extends south of the 49th parallel into the American state of Minnesota, and everywhere presents a rich level prairie, only broken by slight gravel ridges which have formed shoals in the ancient lake." Fossils plants.

Extensive exposures of the palæozoic rocks, which as already stated are supposed to underlie the superficial deposits of the first prairie steppe, occur on many of the islands and along the whole of the western shores of Lake Winnipeg. They form the Grand Rapid of the Saskatchewan, and crop out at intervals along the river as far up as Cumberland or Pine Island Lake. Thence to a considerable distance above Carlton, the valley of the Saskatchewan is occupied by drift and superficial deposits completely covering up and concealing the older formations. This great belt of palæozoic rocks is supposed to have an average width of from sixty to seventy miles, and apparently extends in British territory from the 49th parallel to the mouth of the Mackenzie River in the Arctic Ocean. Palæozoic rocks of the first prairie steppe.

In the comparatively few localities where the rocks composing it have been examined they appear to be characterized, like the formations of the same age in Western Canada, by deposits of salt and petroleum giving rise to copious springs of these valuable materials. And there seems but little doubt that Canada has her a salt and oil bearing region surpassing in extent and productive capacity any hitherto developed on the American continent. Almost the only reliable information relating to the geological structure and physical character of this interesting and important region north of the Saskatchewan Valley is to be found in the narratives of Sir Alexander Mackenzie* and of Sir John Richardson,† published respectively in 1801 and in 1851. Salt and petroleum.

*Voyages through the Continent of North America to the Frozen and Pacific Oceans in the years 1789 and 1793.

†Journal of a Boat-voyage through Rupert's Land, 1851.

The first named author states, page 87 of his narrative, alluding to the Forks of the Athabasca or Elk River below Methy Portage: " At about twenty-four miles from the Forks are some bituminous fountains into which a pole of twenty feet long can be inserted without the least resistance. The bitumen is in a fluid state. Heated it emits a smell like that of sea coal."

Bituminous fountains.

Between Methy Portage and Slave Lake indications of salt and bitumen were frequently noted by Sir John Richardson, and on Salt River, an affluent of Slave River from the west and about mid-way between Athabasca and Slave Lakes, which he ascended in 1820 for twenty miles, he states that, " seven or eight copious springs issue from the base of a long ridge some hundreds of feet high, and spreading their water over a clayey plain, deposit much pure common salt." And again, vol. II, page 198, he says: " The Saskatchewan, which is to be considered as the main feeder of the Winnipeg basin, flows from a considerable distance above Pine Island Lake down to Lake Winnipeg over horizontal beds of limestone through so flat a country that the river forks as it would in an alluvial delta. A rich mud is deposited in parts, particularly between Pine Island Lake, and the main stream and round Moose and Muddy Lakes. In Beaver Lake, immediately to the north of Pine Island Lake, the Silurian strata are again seen covering the flanks of the primitive rocks; while to the southward an eminence named Basquiau, lying at the distance of nearly a degree, separates the river valley from the Red Deer Lake and Swan River. As powerful salt springs exist on this eminence we may conjecture that it belongs to the Onondaga salt group."

Description by Sir John Richardson.

Numerous salt-bearing springs, from some of which large quantities of salt have already been produced, have long been known to exist along the borders of Lakes Manitoba and Winnipegosis, as well as at various points southward to the 49th parallel, and have been described by Professor H. Y. Hind, pages 174 and 175 of the Report on the Assineboine and Saskatchewan exploring expedition.

Salt springs of lakes Manitoba and Winnipegosis

Westward from the summit of the ascent to the second prairie steppe, which is marked by the long range of low hills already mentioned extending north-westerly from Pembina Mountain to Basquia Hills, and which attains an average elevation of 1,600 feet, the country on the route which we travelled, especially after crossing the Assineboine River at Fort Ellice, is generally undulating or rolling and often hilly. Some of the hills rise to from 200 to 300 feet, and occasionally to as much as 400 feet above the general level of the prairie, and afford from their summits extensive views of the surrounding country, which every where presents a park-like aspect; belts, patches and clumps of woodland with intervening richly grassed meadows or wide stretches of open undulating prairie interspersed with countless lakes and pools are seen on all sides, while the wonderful variety

Character of the second prairie steppe.

and beauty of the flowering plants, roses, lillies, gentians, sunflowers, larkspur, a beautiful purple aromatic mint-like plant and a host of others lend an additional charm to the beauties of this picturesquely lovely landscape.

Describing this second prairie level Dr. Hector says: "The composition of this second great steppe is very different from that of the first. Sand is the predominating ingredient. Thus at St. Joseph, where the banks of the Pembina River present a fine section of it to its base, the material is a coarse red sand with gravel and boulders. There are no signs of stratification in any part of this deposit as seen at Pembina Mount, but further west, where it assumes a light grey colour and contains a considerable quantity of lime, it is imperfectly bedded. Near Fort Ellice, and at many other parts of the district to the south and west of that place, this deposit is formed wholly of fragments of the underlying Cretaceous shales. At Long River, Forked Creek and many other places it was observed to form only a very thin coating to the Cretaceous rocks. At Fort Ellice the valley of the Assineboine is 240 feet deep, and about 100 feet of that is composed of this drift deposit resting on the Cretaceous beds. On the whole the character of this level as regards its mineral composition is variable and local. Boulders are tolerably plentiful all over its surface, but occur in greatest quantity on the sides and summits of ridges and mounds which rise in groups to the height of from fifty to eighty feet." Dr. Hector's description of the second prairie steppe. Fort Ellice.

Professor Hind states the valley at Fort Ellice to be 240 feet below the plain, and one mile and thirty chains wide, and the river to be 135 feet broad with a mean depth of eight feet. Assineboine Valley at Fort Ellice.

Recent measurements by the Dominion Lands Department shew Fort Ellice to be 190 miles distant on an air line from Fort Garry. Our odometer measurements made the distance by the trail 217 miles, and we arrived there on the 5th of July or in eleven days from Fort Garry.

On the 29th of July we crossed the Quarantine, or Three Creeks, and camped on the flank of the rise to the second prairie steppe, about midway between the Pembina and Riding Mountains, and about eighty-nine miles west of Fort Garry, the barometer indicating an elevation of 911 feet.

From our camp of the 29th July we traversed the second prairie level for a distance of 400 miles, in a north-westerly direction to the foot of the Thickwood Hills, which we reached at a point about fourteen miles west of Carlton, and the following extracts from my note-book will perhaps best serve to shew the general character of the country as observed from day to day.

JOURNAL OF EXPEDITION.

Rat Creek to Rocky Mountain House.

29th July, Camp V., 23.31 miles west of Rat Creek For the last five or six miles the soil is a black sandy loam or sand. Country generally

level and thickly covered with clumps and patches of small poplar and aspen trees with alder and willow brush.

July 30. Camp VI., Pine Creek. We have only made sixteen miles to-day. The country east of Pine Creek passed over to-day is all covered with a light sandy soil, and at this camp the country is very broken: knolls, ridges and hollows entirely composed of blown sand. The grass generally poor and much of the surface occupied by a species of trailing juniper covered with white and greenish-white berries and intermixed with bear-berry (Arctostaphylos uva-ursi). Willow, hazel and cherry are the principal brushwood. Aspen, oak and a few scattered spruce trees constitute the timber, all of small size. Mosquitoes very troublesome.

Sandy country.

July 31. Raining all night; start at 8.50 a.m. At 9.35, in about 2 miles on to open prairie, course West 25°. North from edge of rise from Pine Creek: no sand hills but soil still light and sandy; a good deal of small oak timber on the western slope of the Pine Creek valley. Travelled twenty-six miles to-day, the soil gradually improving, over nearly level and mostly open prairie from which the water drains north into the White Mud River, south to the Assineboine and west to the Little Saskatchewan. A few small fresh, water lakes were passed. 7.30 p.m., camped on the prairie.

August 1st. Boggy Creek Plain camp. Started at 7.30 a.m. After crossing open prairie for some distance we passed into a country mostly covered with brushwood and coarse grass. It consists of a series of rises and depressions, the former in ridges and the latter in more or less circular holes which retain the water in the spring from the melting snow, but are now nearly all dry and covered with long coarse grass. On the ridges gravel often shews on the surface, and there are many large scattered blocks of gneiss, and others of white or buff-coloured limestone. Some of the gneiss blocks measure from 8 to 9 feet on the exposed surfaces. The surface soil is a fine rich black loam, rather thin on the crests of the ridges. Beneath the black soil is a brown clay-earth mixed with small limestone pebbles. A hole dug two feet deep on the ridge we camped upon at noon shewed ten to twelve inches of black soil underlaid by a brown clayey silt. At 5.30 p.m. we crossed the Little Saskatchewan or Rapid River and camped on a terrace about half way up the right bank, having travelled a little more than twenty miles. The valley of the Little Saskatchewan has been fully described by Professor Hind in his Report already cited.

Large boulders.

Little Saskatchewan River.

August 2nd. Started at 6.4 a.m., and at 11.45 reached where the road from Prairie Portage via the White Mud River comes in, 17.42 miles from the Little Saskatchewan. Here a small water-hole on the open plain affords the only fresh water for a stretch of nearly thirty miles. Several shallow saline lakes were passed to-day. In some the water was quite evaporated, and in all the flat borders were fringed with samphire, *Salicornia*, the red tint of which serves even at a distance to distinguish these saline lakes

from those holding fresh water. Blocks and boulders of gneiss and limestone, especially the former, are very abundant on the surface of the plain. The soil lighter but still black and apparently well suited for cultivation. Travelled twenty-two miles. Good soil.

August 4th. Camp IX., five miles east of Shoal Lake. Elevation, 1520 feet. Start at 6.15 a.m., reach Shoal Lake 7.45. This lake is a fine sheet of fresh water several miles in length and about half a mile wide, surrounded by gravelly banks and discharging by a clear shallow stream—Oak River—into a lower lake having a direction nearly east and west or at right angles to that of the upper lakes, and occupying a broad swampy flat nearly a mile in length. The cart trail passes along the northern side of the lower lake and crosses the stream at the outlet of the upper lake. Around the lake the soil is light, sandy and gravelly, but improves again at a short distance. There is no change in the general character of the country or of the vegetation ; scattered blocks and boulders of gneiss and white magnesian limestone are very general. On the whole, the country traversed to-day—27.24 miles—does not present generally a very inviting or fertile appearance. The soil is certainly poor, the grass coarse and wiry looking, and especially on the ridges where beneath a rather thin black mould is a poor white gravelly substratum, it presents a brown and withered aspect. At 6.15 p.m. camped on the right bank of Bird Tail Creek at about 80 feet below the level of the plain. Shoal Lake. Birdtail Creek.

August 5th. Start at 7.30 a.m. Leaving Bird Tail Creek the trail again ascends to the level of the plain, and in about six miles strikes the head of a narrow dry valley. Following this down for about a mile it turns to the right up another somewhat wider valley in which is a small unnamed creek and crossing this again reaches the plain by an abrupt ascent. Thence to the edge of the descent to the Assineboine River, opposite Fort Ellice, is a further distance of about five miles over a rather stony plain with a light sandy loam soil, underlaid by gravel. The descent from the plain towards the river is by two distinct steps and broad terrace-like plateaux, the second step being that, the edge of which immediately overlooks the Assineboine Valley, and is as already stated about 240 feet above the river at its base. At about 100 feet below the level of the plain there are numerous springs of good water, which probably mark the junction of the drifts with the underlying Cretaceous shales, though the latter were nowhere exposed to view. From immediately in front of the fort, which is situated at about two miles below the confluence of the Qu'Appelle River, the west side of the valley slopes steeply down to the Assineboine. Inside the fort, at 330 yards from the edge of the escarpment, a well has been sunk in the drift, and at thirteen feet an abundant supply of excellent water was obtained which rises to within nine feet from the surface, giving a permanent depth of about four feet of water in the well. Springs. Well at Fort Ellice.

August 6th.—Left Fort Ellice at 2.30. p.m., and after passing over about two miles of rather rough country—poplar groves interspersed with swampy flats and stony rises—reached the descent, a thickly wooded slope, to the valley of the Qu'Appelle River, which we crossed at about two miles above its junction with the Assineboine. The Qu'Appelle River is only about fifteen yards wide and two-and-a-half feet deep, with a hard gravelly bed. On the north side of it sand is the prevailing feature, both along the valley and on the hills, and intermixed with it are numerous large blocks and boulders of gneiss. A similarly sandy and arid looking country appears to extend for a long distance in a westerly direction up the Qu'Appelle valley.

Valley of the Qu'Appelle River.

August 7th.–After crossing about fifteen miles of mostly open plain, rather thinly grassed, with occasional willow and poplar clumps, the trail crosses a large swampy flat covered with long green grass, to the right are several rounded hills and ridges of drift consisting of small rounded pebbles mixed with sand. From one of these, Spy Hill, though not more than from fifty to sixty feet above the level of the plain, an extensive view is afforded of the surrounding country. Low drift hills and ridges, with intervening swampy flats and a few lagoons, lakelets, and scattered clumps of small poplar and brushwood, are seen on all sides as far as the eye can reach. At 7.30 p.m. camped on the west side of Big Cut-Arm Creek, having travelled 28.92 miles, the whole distance through country similar to that described above. The soil generally light, sandy and gravelly. The hills and ridges made of a drift of small water-worn pebbles and whitey-brown sand thinly covered by a dark vegetable mould. In the flats and low-lying lands, there is always a deeper and richer soil clothed with long coarse grass. The valley of Big Cut-Arm Creek is about 800 yards wide and from ninety to 100 feet below the prairie level; the stream about twenty-five feet wide and two feet deep with a strong current. The western slope, or that facing east, is thickly covered with brushwood and small poplar, while the eastern slope is almost bare.

Drift hills.

BigCut-Arm Creek

August 8th.—But little change in the character of the country passed over to-day as regards the soil, the first part, to our mid-day camp, is rather thickly wooded with the usual stunted poplar in clumps and patches, no other trees whatever. The sub-soil, a white gravelly sand; the grass generally poor and brownish except in the depressions and dried up swamps; the latter part an open plain devoid of timber, so that we had to carry wood with us for our night's encampment; distance travelled 21.93 miles.

August 9th.—Started at 5.10 a.m. Open undulating plains on all sides as far as the eye can reach, soil somewhat better. At 7.50 we halted to get breakfast, a hole dug two feet deep showed one foot of black mould underlaid by a fine brown silt with a few pebbles. At 6 p.m. camped on open prairie above Pheasant Hill Creek, having travelled nearly thirty miles. To the north-east and south an undulating often hilly treeless prairie. The hills and ridges all of water-worn gravel, chiefly of gneiss, and encrusted with white carbonate of lime.

Pheasant Hill Creek.

August 11th.—Off at 5.40 a.m. Course west, towards some timber bluffs extending from the Pheasant Hills, which lie a few miles to the left and appear to be thickly wooded. Halted at noon for three hours, and then travelled till 6.30 p.m., having made 28.30 miles. The country presents no marked change: lakes and lake basins more abundant, the water in many of them slightly brackish. They appear all to be gradually diminishing in size and drying up. This, Macdonald tells me, has been going on steadily for several years. He says that what were large lakes are now small pools, and all the lesser ones are already quite dry, and their beds overgrown with grass and weeds. The soil and sub-soil, which are frequently exposed to view by the holes of the badgers and "gophers" consist of a black, light vegetable mould resting on a whitish-coloured silt passing down into a well-rounded gravel. For the last few miles, the country is so thickly covered with clumps or "bluffs" of poplars, with an undergrowth chiefly of willows, as to give it from a distance the appearance of an uninterrupted copse-wood. The surface is very ridgy and undulating, and the general luxuriance of the grass indicates a fertile soil. Lakes drying up.

August 12th.—Camp XVI. File Hills. Rain fell during the night. Start at 6.50. a.m. At 6.15. p.m., camped on the border of a small lake, having travelled 24.70 miles. The country passed through to-day is in parts very picturesque, undulating and sometimes hilly, and prettily dotted with patches of woodland and interspersed with lakes and pools. The trees are all poplar with undergrowth of willow; but the former are larger than we have seen since leaving Fort Ellice. In some of the lakes the water is quite salt; in others only slightly brackish but quite drinkable. In using it for washing it leaves a roughness on the skin and curdles the soap. Soon after sunset rain commenced falling accompanied by thunder and lightning, and continued till daylight. Picturesque country.

August 13th.—At noon we reached the base of the Touchwood Hills, and after dinner, taking Fisher with me as guide, I left our party to proceed on the direct route to the old and now deserted Touchwood Hills post while I diverged to the left to visit the Little Touchwood Hills post and mission about 15 miles to the south-west. The trail we followed is very circuitous and hilly, passing numerous lakes and pools; the country for the most part covered with thick copse-wood and the fort itself surrounded by extensive woods. We arrived there at 7.45 p.m., and were hospitably entertained by the Rev. Mr. Pratt, Church of England missionary and a full-blooded Indian. Around the fort the best timber has been cut, but Mr. Pratt informed me that at a short distance there were plenty of large sized white birch, and abundance of poplars, as much as two feet in diameter, suitable for joists, flooring-boards, &c. Mr. Pratt's house stands on an eminence above a small lake with swampy margins and about one mile from the Hudson's Bay post, near which is another similar lake. The Touchwood Hills. Large timber

Rich soil.

The soil is a rich light brown loam, and would doubtless produce excellent crops. The view from the post is limited on all sides by forest, but it must be situated on the eastern flank of the Little Touchwood Hills.

August 14th.—Started at 7.45. a.m. for the old Fort where I expected to find our train. Mr. Pratt estimated the distance to be ten miles, but my odometer showed it to be only a little less than 16. We reached it, or rather the site where it once stood, as no trace of it now remains, at 10.45 a.m., and found our party encamped and breakfast just finished, they having arrived an hour before. The beauties of the Touchwood Hills have been so graphically described by Professor Hind, that I cannot do better than reproduce what he says of this really lovely tract of country. Professor Hind approached them from the west, and from this direction they present a rather bold outline, marked, however, by only one or two prominent points of which the Heart Hill is the most conspicuous. The range has a general north-easterly and south-westerly trend, in which direction it gradually sinks to the valley of the Assineboine on the one hand and to the Qu'Appelle on the other. Professor Hind says, under date 15th of August, 1858: "In the afternoon we began the ascent of a gently rolling slope at the foot of the Touchwood Hills; patches of willow appear here fringing small areas of good pasturage. At 6 p.m. we reached the summit plateau and then passed through a very beautiful, undulating country diversified with many picturesque lakes and aspen groves possessing soil of the best quality and covered with the most luxuriant herbage. There is no timber visible on the west side of the range with the exception of small aspen and burnt willow bushes. All the wild flowers, so beautiful and numerous in the valley of Long Creek, are met with on the summit plateau of the Touchwood Hills, of even larger growth and greater profusion. Little prairie-openings fringed with aspen, occur here and there through which the trail passes; we then come suddenly on to the banks of a romantic lakelet, in which ducks with their young broods are swimming, and white cranes start from their secluded haunts at the unexpected intrusion. The breadth of this beautiful plateau is about four miles, its level above the Salt Prairie to the west may be about five hundred feet. The fort is situated on the south-east flank of the range, and from a hill close behind it an extensive view of the country is obtained. Heart Hill is about seven hundred feet above the level of the plain and seven miles in an air line N. 12° W. of the post. The general direction of the range is N. 26° E. It appears to consist of a series of drift hills, many of which rise in rounded dome-shaped forms from the summit plateau."

Professor Hind's description of the Touchwood Hills.

Heart Hill.

The above description is applicable to nearly the whole of the country between the old post and the Little Touchwood Hills Fort, the trail between the two running along the summit plateau and near its western edge for the greater part of the distance. On the flanks and summits of most of the

ridges and rounded dome-shaped hills there are many large angular, evidently ice-borne, blocks and masses of buff-coloured Silurian limestone with others of gneiss, mica schists, diorite and other crystalline rocks. Ice-borne boulders.

Descending from the Touchwood Hills immediately to the westward the Great Salt Plain, utterly devoid of timber, stretches away to the distant horizon. At 12.27 miles from the site of the old post we came to the first drinkable water on the great plain, alongside of which we encamped, having carried firewood with us from the base of the hills. Almost everywhere the surface of the country presents a peculiar aspect arising from the innumerable circular, oval or elongated pits and depressions which occur both amongst the hills and on the plains. Hundreds of them are not more than from one to perhaps three chains in diameter, three to six or eight feet below the general level and flat bottomed and swampy, and fringed with low willow bushes; sometimes they contain water, but at this season are for the most part dried up and the surface clothed with long grass. Others are of larger dimensions, enclosing saline and brackish water lakes, none of which have any visible outlet. Apart from the vegetation, the outlines of the country altogether forcibly reminded me of representations of the surface of the moon. This plateau forms the watershed between the Qu'Appelle to the south-west, and the Saskatchewan and Assineboine to the north-east. A very small proportion of the water which falls upon it passes off by surface drainage. Rapid evaporation during summer and probably a considerable amount of percolation through the sandy drifts removes the remainder, and these causes are quite sufficient to account for the generally saline character of the numerous lakes and pools. Many of these saline lakes are as much as three, four or five miles in length, and occasionally from one to two miles wide. They occur either in isolated irregular basin-shaped hollows or forming chains of lakes in rather broad valley-like depressions extending many miles, but closed in on all sides by rounded drift-formed hills with grassy slopes. When occurring in this manner the lowest lake in the chain receives the drainage of the others, and I observed in all such cases that while the water of the uppermost lake was either quite fresh or only slightly brackish, that in the lowest lake would be intensely salt and bitter. This peculiarity may also be observed to affect isolated lakes or pools near each other, situated at different altitudes, and the traveller seeking good water should always do so in those pools or lakes which occupy the most elevated positions, and which consequently receive their water by precipitation only and not by percolation or surface drainage from higher levels.

Great Salt Plain.

Curious pits and depressions

Large salt lakes.

Where to seek for good water.

August 15th.—Camp XIX., 12.27 miles west from the old Touchwood Hills post and 372.47 miles from Fort Garry. Barometer 28.18, thermometer 36° at 4.30 a.m. Started at 5 a.m and made 27 miles, camp-

ing at 5.45 p.m. We have been travelling all day over the "Great Salt Plain," a treeless prairie. In the depressions for the last six miles dwarfed poplars and willow bushes from three to five feet high prevail. The soil is a blackish loam, rather sandy, on a sub-soil of white looking gravel. Limestone and gneiss in large and small blocks are pretty thickly distributed over the surface.

August 16th.—Start at 5 a.m., made two short halts for breakfast and dinner, and travelled till 8.15 p.m. not being able to find water earlier. Distance travelled 36.08 miles; country rather more undulating; for the most part open prairie; wood and water scarce and far apart.

Scarcity of wood and water.

August 17th, Sunday.—This camp is on a grassy flat some fifty or sixty acres in extent, apparently a dried up lake bed about 100 feet below the level of the plains and surrounded on all sides by rather steep hills, covered on their flanks and summits with large ice-borne boulders, limestone, gneiss, etc. As there was no wood and but little water near the camp, we moved after breakfast to a favourite camping ground about two miles distant at the base of an eminence known as the Big Hill. Quite recently a substantial and conspicuous wooden cross has been erected on this hill by a travelling party of Roman Catholic Missionaries, who at the same time have re-christened it by the more classical if not as expressive name, Mount Carmel. It rises to about 140 or 160 feet above the road at its base, and from its summit an extensive view is afforded of the surrounding country especially to the westward, in which direction there is a general fall towards the valley of the South Saskatchewan. Mount Carmel seems to be entirely composed of drift, and on its flanks and summit, which are partly covered with aspen and willow copse-wood, there are numbers of large angular boulders of buff-coloured limestone holding fossils, garnetiferous gneiss and mica schist and slaty diorite. In some directions as far as the eye can reach similiar hills and ridges follow each other in endless succession and apparently without definite arrangement or parallelism. From the lowest depressions to the summit of the highest ridges is often not less than 300 feet, and from Mount Carmel I counted fifteen distinct lakes and pools, while many more were only concealed from view by intervening ridges.

Mount Carmel or the Big Hill.

August 18th.—Started at 6.30 a.m. on a course north 35° west for twelve and a-half miles through the Rainy Hills—low drift hills interspersed with many lakes and pools and clumps and patches of copse-wood with intervening open grassy plains. Camped at 6.20 p.m., having travelled 24.28 miles.

The Rainy Hills.

August 19th.—Started at 6 a.m., and soon came in sight of the Minitchenass or Lumpy Hill of the Woods, and when we camped at 6.45 p.m. two miles from the crossing place on the South Saskatchewan, having travelled 37.74 miles, it was still a conspicuous landmark.

Lumpy Hill of the Woods.

The Lumpy Hill of the Woods was ascended and examined by Professor Hind, and is thus described by him, (page 67, Report on the Assiniboine and Saskatchewan Exploring Expedition): "The view from the Lumpy Hill which I ascended this evening is very extensive. The altitude of this eminence is about 400 feet above the general level of the country. From its summit an undulating open country dotted with lakes and flanked by the Birch Hills is visible towards the east. South and south-west is a lake region, also north and north-east. These lakes are numerous and large, often three miles long and two broad. Seventeen large lakes can be counted from the Lumpy Hill; hill ranges in several directions can be discerned. The most important of these are the Bloody Hills, the Woody Hills far in the prairie west of the South Branch, and the chain of Birch Hills running from the Lumpy Hill easterly. Low hills and long ridges running north-east by east and south-west by south diversify the general level character of the plains as seen from the Lumpy Hill. This eminence consists of drift sand and clay with boulders on its summit. The western side is very steep, and partially covered with a burnt forest of birch." Professor Hind's description of the Minitohenass.

Of the country in the wooded belts between the Lumpy Hill and the Big Hill or Mount Carmel, Professor Hind says: "There are many delightful spots in the belts, the herbage is clean as a well shaven lawn, the clumps of aspen are neatly rounded as if by art; and where little lakes abound alive with water fowl, the scenery is very charming and appears to be artificial, the result of taste and skill rather than the natural features of a wild and almost uninhabited country."

August 20th.—Started at 5.15 a.m., and at 6 a.m. reached the crossing place of the South Saskatchewan. The river here is about 200 yards wide, with a strong swift current. The extreme width of the valley from the level of the plain on either side is in some places nearly two miles, and the descent to the river is by a succession of steps or terraces; occasionally four distinct steps are visible of from twenty to sixty feet high, and the tread varying from a few yards to upwards of half a mile in width. When these occur on one side of the river, the opposite bank generally rises abruptly to the level of the plain, presenting cliffs from 140 to 150 feet in height of brown earthy clay or loam with occasional, large imbedded boulders. The river is now from six to eight feet below high water level, and at the bends stretching away from the base of the cliffs, are long points formed of large boulders of limestone and gneiss, the latter generally rounded and water-worn while the former are often as sharply angular as if recently taken from their bed. Blocks measuring 6 x 5 x 3 feet are not uncommon, and nearly all of them are scratched and grooved by ice. Ironstone nodules, some of large size, are also abundant amongst the boulders. There are no unmoved rocks of any kind in the South Saskatchewan crossing. Ironstone nodules. No rocks in situ.

vicinity, and whether the superficial deposits here are immediately underlaid by Cretaceous, Devonian or Silurian rocks can only be ascertained by boring.

Owing to a stiff breeze blowing all day against the current, and the shaky condition of the punt kept here by the Hudson's Bay Company, we were unable to cross the river till late in the afternoon. At 6 p.m., having got everything over safely, we ascended the steep bank on the opposite side and camped.

Cross the South Branch.

August 21st.—Started early and reached Carlton House on the North Branch shortly after mid-day, distance by odometer 19.6 miles from the South Branch crossing, and 511.73 miles from Fort Garry. The fort, the usual square palisaded structure, enclosing the dwelling houses, stores and workshops, with flanking towers at each angle, stands on a terraced flat of limited extent about 200 feet below the level of plain. Between it and the river a second narrower terrace or alluvial flat, about fifteen feet below the first, borders the river, and is only a few inches above high water mark. A short distance above the fort, on the leftbank, the terraces terminate and a single steep slope rises from the margin of the river to the plain, while on the opposite side, the terraced character of the valley appears to have been modified by successive land-slides producing a wide broken surface of irregular hills and hollows, which are for the most part thickly wooded. The North Saskatchewan at Carlton is about 400 yards wide, with an extreme depth of about ten feet. For nearly half the distance horses can cross now without swimming. The channel seems to be much cut up by sand-bars and shoals, which are annually changing both in position and extent.

Carlton House.

August 22nd.—The afternoon of yesterday and to-day engaged rearranging our loading, storing provisions required for the return journey, and getting carts and horses across the river. This having been successfully accomplished we proceeded about two miles and camped at 5 p.m. Soon after the tents were pitched, heavy rain commenced with gusty wind from E. S. E., lasting till 8 p.m.

Cross the North Saskatchewan.

August 23rd.—Seven a.m. It has been raining heavily the greater part of the night and still continues. Barometer 27.92, thermometer 58°. 11 a.m. wind changing to north-west and rain ceasing. 2 p.m., thermometer 60°, barometer 27.96. Struck camp and started. The soil here is very sandy and light. At 5.10 p.m. we reached the "Creek on the Prairie," a deep water channel with very little current, about one chain wide, connecting a series of lakes and large swamps swarming with snipe, plover and wild-fowl. To cross it without wetting our provisions we had to raise all the loading in the carts on to stages laid across the top rails, and the water was nearly two inches over the seat of the buck-board. This is the

Abundance of game.

worst crossing between Fort Garry and Edmonton, and a bridge or ferry is much needed, and would be a great boon both to travellers and freighters. We effected the passage without accident and camped at 5.30 p.m. on the west bank, having with difficulty found a dry spot, which was, however, surrounded on all hands by extensive grassy swamps ; no trees of any kind, and we had to bring firewood with us from the last timber " bluffs" which we passed some two miles distant to the eastward.

August 24th.—Dense fog and heavy dew this morning : thermometer 53° at 6 a.m., barometer 28.20. Started at 7 a.m. and travelled 15.95 miles to the right bank of Redberry Creek ; the road passes over a very hilly and broken country interspersed with lakes swarming with ducks, teal and other water-fowl. This country is the eastern slope of the Thickwood Hills which form the ascent to the level of the third prairie steppe. Redberry Creek flows into a large salt lake known as Redberry or Big Salt Lake. At 5 p.m. we reached Bear Paddling Lake, and camped on the north side of it, having made 24.3 miles. The road travelled this afternoon through the Thickwood Hills is very rough and stony, boulders having again become numerous, while from the base of these hills to Carlton very few are seen. As the name implies, the country is comparatively well wooded, and grass is everywhere abundant. The barometer this evening reads 27.50, a difference since morning of 00.70.

Redberry Creek.

The Thickwood Hills.

August 25th.—5.30 a.m., barometer 27.55. Start at 6.25 a.m., the road passing over a very slightly rolling, treeless prairie. At 10 a.m. we came to the edge of a steep hill stretching a long distance to the right and left and bounding a wide grassy flat with a small creek running through it. On all sides it is bordered by steep rounded knolls and ridges, and the descent to it is not less than 100 feet. It has probably once formed the bed of an extensive lake with long narrow bays or arms and numerous islands. There is but little change to note in the general aspect of the country. We have travelled 30.15 miles, the greater part of the distance through country almost bare of wood. The ridges and hills are composed of sand and gravel; the soil is generally light and poor ; grassy margined lakes and pools, many of them salt, abound, and the surface is very irregular and broken, presenting a succession of saucer-shaped depressions with intervening low mammaloid hills and rounded ridges of drift, with grassy or occasionally partially wooded slopes, and on the surface scattered blocks and boulders of gneiss and buff-coloured, fossiliferous limestones. At 5.30 p.m. we camped on the crest of one of these ridges with three lakes in sight in the surrounding depressions.

Old Lake basin

August 26th.—Started at 6.15 a.m. and travelled 18 miles to Jack-Fish River. This river discharges Jack-Fish Lake. Where the road crosses it, it runs through a wide grassy flat, at the general level of the prairie. The current is strong and swift; the bed full of large boulders and the

Jack-Fish River.

D

water about three to four feet deep and fifty or sixty feet wide ; it is the largest northern tributary of the Saskatchewan between Carlton and Pitt. We did not see the lake. Dr. Hector, who examined it in 1858, says: "Jack-Fish Lake is divided by a narrow strip of land into two portions, the whole being about twenty miles long and twelve miles wide. Its water is slightly saline, but as it is fed by several large streams, while a large river flows out of it to the Saskatchewan, its waters never become concentrated like those of Redberry Lake, from which there is said to be no outlet. The lake freezes early in the winter except at the north-east corner, where a large stream enters it, and where it remains open during the whole year. Here the Indians spear an immense number of pike, as the open water which is shallow and sedgy is actually crowded with them. Whitefish are also taken in considerable numbers with perch and other fish, and there are always Indians living in the neighbourhood of this lake, on account of the constant supply of food which it affords."

Jack-Fish Lake.

Rich soil.

The soil for many miles is of the finest quality ; a rich black loam on a blueish-grey clay. The surface is thrown into large hillocks by the moles, and gophers, or marmots, rendering it very rough and unpleasant to travel over. At 6.15 p.m. camped on the summit of a low ridge, having travelled 28.47 miles. From Jack-Fish River westward, the country is tolerably level and thickly dotted with patches of copse-wood. Around our camp there are several shallow saline and fresh-water lakes swarming with wild-fowl.

Turtle River.

August 27th.—Camp XXXI. Ten miles west of Jack-Fish River. Barometer 27.92, thermometer 54° at 6 a.m. Started at 6.30 and at 10.20 reached Turtle River, having travelled 15.71 miles through a fine fertile country. Turtle River is a rapid stream about the same size and volume as Jack-Fish River and the Little Saskatchewan. At the crossing place the water is rather more than three feet deep. Judging from the volume of water in both Jack-Fish and Turtle Rivers, they must both drain a very considerable tract of country; but they have never been surveyed or examined, and their sources are unknown. It has been raining slightly all the forenoon, and at 3 p.m., it having again commenced to rain, we camped. Before the tents were pitched it was falling in torrents, accompanied by thunder and lightning. At 9 p m. barometer 27.52, thermometer 56°, still raining.

August 28th, 6 a.m.—A very rough wet night and still raining with a strong southerly wind, barometer 27.46, thermometer 49°, too wet to travel. 9 p.m., rain over, fresh south-west wind, barometer 27.87, thermometer 51°.

English River.

August 29th.—6 a.m., barometer 28.00, thermometer 41°, fine and clear. Started at 6 a.m., and at 9.20 crossed English River, a small stream about twelve feet wide and two feet deep. On this stream, about one mile

below the crossing, the first spruce trees seen since leaving Fort Ellice were observed. On the hill above the crossing place, and close on the right hand side of the trail, there is an enormous angular block of cream-coloured limestone. It measures ten feet square on the top, is about three feet thick and twelve yards round at the base. At 5.30 p.m. camped nineteen miles from Fort Pitt on the south-east side of a large fresh-water lake, one of a chain of lakes which empty into Red Deer Creek. To the south-east the Red Deer Hills rise some two to three hundred feet above our camp. We have travelled 31.4 miles to-day through a rather pretty park-like country. In places stoney and gravelly ; the soil a light sandy loam, and in parts, especially a few miles on this side of last night's camp, all sand and very poor. Dwarf juniper and the red-berried trailing bear-berry forming a carpet on the surface. Small clumps of willow and poplar in the hollows. Spruce trees. Red Deer Hills.

August 30th.—4 a.m., barometer 27.85, thermometer 58.° Start at 5 a.m. with Mr. Roberts for Fort Pitt, leaving the rest of the party to proceed by the more direct road to the upper crossing of Pipe-stone Creek. The road which we followed after crossing Red Deer Creek turns to the left and passes by a steep descent down into the valley of the Saskatchewan, striking the river near the northern extremity of the great south bend about six miles below the Fort, which we reached at 9 a.m., having travelled 18.65 miles.

Fort Pitt is situated on a narrow flat close to the river bank and about fifteen or twenty feet above the water. The soil is a rich black mould about three feet in depth underlaid by a coarse rounded gravel. On the hills at the back, the soil is a brown sand and sandy gravel, not suitable for cultivation. There are fine crops of barley and potatoes at the Fort, the latter now being used, and the former would also have been ripe but was cut down in July by a heavy hail storm. Wheat has not been grown at Fort Pitt but barley is almost always a successful crop. This year, however, it will probably be cut by frost before it has time to ripen. We left the fort at 3 p.m., and ascending the hills at the back, overtook our train on the road a few miles west of Pipe-stone Creek. At 6.16 p.m. we camped, having made 14.2 miles from Fort Pitt and 32.85 miles from our last night's camp at the Red Deer Lakes. Fort Pitt.

August 31st.—Started at 7.10 a.m., made 13.75 miles and halted for dinner at 11 a.m. The country traversed this morning is of the usual hilly character with intervening swampy flats and pools. Spruce trees, *Abies alba*, are here tolerably abundant; there are also clumps of pine and a few larch trees. The soil is generally sandy and gravelly with a thin layer of light black loam on the surface. Prairie chicken very numerous. At 5.30 we crossed Frog Creek, a rapid stream 50-60 links wide and three feet deep, and at 6.15 p.m. camped on the summit of a high ridge overlook- Frog Creek.

ing the Frog Lakes lying to the north and north-west. The country traversed this afternoon, 12.45 miles, is all hilly and rather thickly wooded. Lakes and pools are numerous. One large salt lake was passed, the road for some distance passing along the beach.

September 1st.—6 a.m., fine clear morning, a thick fog resting on the lakes, heavy dew on the hills, barometer 27.83, thermometer 46°. Start at 6.15 a.m. Rock Creek, Moose Hill Creek and Dog Rump Creek were crossed to-day. The latter is narrow, about four feet deep and boggy on the banks. A small brush bridge has been built across it, but as it was not safe for horses we unharnessed them and drove them through the Creek drawing the carts over ourselves. At 6 p.m. camped in the valley of Dog Rump Creek, about half a mile west of the crossing place. We have travelled 28.23 miles to-day. Two species of pine, and spruce trees, were observed at intervals all along our route; small poplar thickets everywhere, with numerous swampy creeks, pools and lakes, between ridges and hills of sand and gravel, occasionally large boulders on the surface, nearly all of gneiss and granite. During the past two days very few limestone boulders have been seen, and to-day none. The valley of Dog Rump Creek is nearly two miles wide and about 200 feet deep. The terraces along its sides are very marked, shewing two broad steps from the valley to the plain above. The valley itself has the appearance of a wide flat scored by numerous channels, between which there are left a number of ridges and table-topped hillocks of gravel and boulders, marking the height of what must once have been the surface of the valley. This valley would be a good site for boring to test the extension of the Edmonton coal beds.

Dog Rump Creek.

Absence of limestone boulders.

September 2nd.—5.45. a.m., barometer 27.32; thermometer 46°. Start at 6.00 a.m., at 6.20 reached the prairie level; barometer 27.32, indicating a rise of 180 or 190 feet. At 9.45 came in sight of a large lake lying close on the left of the road. This lake is not indicated on the maps, but is known as Egg Lake. At 11.10 halted for dinner, having made 15.76 miles; barometer 27.21. The Snake Hills bear west 40° south about 15 miles distant.

Egg Lake.

At 5.30 p.m. we camped on the south side of Saddle Lake, having travelled 24.79 miles. But little change in the character of the country; wood less plentiful, only scattered poplar and willow coppice, with here and there a few spruce, pine and larch. Nearly all the older trees have been destroyed by fires: rich black soil; a few boulders, gneiss and granite: good pasturage everywhere: two species of vetch or "pea-vine" very abundant and luxuriant.

September 3rd.—Start at 6.15 a.m., thermometer 46°. At 10.50 halted for dinner, having travelled 14.9 miles of the worst road we have yet encountered; the latter part of it, across a wide, swampy, willow-covered flat, mud and water up to our horses' knees for several miles. At 5.30 camped

on a small creek twelve miles from Victoria, having made 27.60 miles. This afternoon we struck one of the heads of Little Vermillion Creek which we followed down for several miles through a narrow valley. Much of the country here is sandy, and the ground is covered with trailing juniper and bear-berry, (*Arctostaphylos uva-ursi*,) and in places thick pine and spruce forest; the trees, however, all of small size. 9 p.m., thermometer 44° **Little Vermillion Creek.**

September 4th.—4 a.m., thermometer 28°. Start at 6.15 a.m. and reached Victoria, Hudson's Bay post and Wesleyan Mission station at 9.15. The greater part of the road is sandy, through thick forest of small pine and spruce; bear-berry and cranberry very abundant. In the garden at the Mission there were turnips, potatoes, cabbages, carrots, onions, parsnips and pumpkins, all growing luxuriantly: the wheat and barley sown in May are also very fine, the latter now being harvested. The soil is a rather light, sandy, black loam. The sharp frost last night cut the pumpkin, tomatoe and potatoe plants, but the wheat does not appear to have suffered from it. **Victoria.**

Victoria is in longitude 112°, west, latitude 54° north; 813 miles from Fort Garry and about 1900 feet above the sea.

September 6th.-Started at 5.30 a.m., thermometer 40°, barometer 28.10, At 10.40 halted for dinner on the left bank of Carp Creek, a strong clear stream with gravelly bed about fifty feet wide and two feet deep, 21.73 miles from Victoria. At 5 p.m. crossed Vermillion River, called White Earth Creek on Palliser's map, and camped on the west bank. This is also a strong stream about one chain wide and three feet deep. Carp and Vermillion Creeks are probably the outlets of large lakes on the height of land between the Saskatchewan and Pembina River, but they are not laid down on any existing maps, and have probably never been explored. For the last fifteen miles the road is very bad, alternations of boggy water-holes and sandy hills, all the way through thick woods. In the low parts poplar and birch; spruce and pine on the sandy ridges. **Carp Creek and Vermillion River.**

September 6th.—4 a.m., thermometer 24°, grass quite white with thick hoar frost. Start at 6 a.m. and reached Edmonton at 4.30 p.m. thirty-five miles from Vermillion River. No change in the character of the country. Stretches of open prairie well grassed, alternating with belts and patches of woodland, the greater part of it being well adapted for settlement.

At about 23 miles from Edmonton the road crosses Sturgeon River, which drains a large tract of country lying to the west and north-west of Edmonton, including Lake St. Ann and a number of other smaller lakes. It has a course of nearly eighty miles, and carries a large body of water. Where the road crosses, it is about seventy feet wide and three and a-half to four feet deep. All the creeks have hard sandy or gravelly beds and are therefore fordable without difficulty or danger. Edmonton House stands on the left bank of the Saskatchewan overlooking the river **Sturgeon River. Edmonton.**

and about 100 feet above the water. At the back of the fort the ground rises by a gradual ascent another 100 or 150 feet to the general prairie level. Dr. Hector thus describes the valley at Edmonton: "At Fort Edmonton the banks of the river valley are from 190 to 250 feet high, and at most places densely wooded. Seven to ten miles back from the valley, on either side, is a line of high ground rising from 200 to 300 feet above a willow covered plain."

St. Albert R.C. Mission.

September 7th.—Visited St. Albert R.C. Mission station and Orphanage, nine miles west of Edmonton, presided over by Père Le Duc, by whom we were most kindly received and hospitably entertained. In the orphanage there are thirty Indian and Half-breed children. A fine farm and garden some forty or fifty acres in extent is cultivated by the missionaries. In the fields there were splendid crops of barley, wheat, potatoes and turnips, and in the garden a variety of other vegetables. The barley was just cut, the wheat not quite ripe and some of the ears frosted. Père Le Duc says wheat has hitherto proved an uncertain crop, having very frequently been cut by frost before ripening. Some more hardy kind, or fall sowing, which has not been tried, might produce better results.

September 8th—Making arrangements to start to-morrow for Rocky Mountain House. In the afternoon examined the left bank of the river for a mile and a-half below the fort. Found two thin seams of coal with a black earthy shale and layers of grey clay-shale between them, the former made up of indistinct plant remains looking like grass and sedges.

Soap clay.

Immediately above the coal seam is a layer of a brown greasy clay six or eight inches thick. This clay works into a lather like soap, and Dr. Hector says it was used by the women at the fort for washing blankets. A sample of it, analysed by Mr. Hoffmann in the Survey laboratory, shews it to be a hydrous silicate of alumina*

The upper part of the bank is either a brown clay-earth or a rounded gravel. Owing to the slides in the banks caused by springs, the strata are so much covered up that the thickness of the several beds is not easily ascertained. I did not examine the opposite bank of the river. Dr.

Section at Edmonton.

Hector gives the following section of it, a short distance below the fort:—

Superficial gravel and sand	7. 0
Grey sandy clay	8. 0
Lignite	1. 0
Shale	11. 0
Lignite	2. 0
Clay sandstone	10. 0
Lignite very pure	3. 0
Concretionary green sand	12. 0
Lignite very pure and compact with six inches of	0
Soap clay	6. 0
	60. 0

*For analysis and description of this soap-clay see Appendix

The strata are generally nearly horizontal, though occasionally presenting a slight dip, three or four degrees, to S. 29° E. A nodular clay iron ore occurs in layers associated with the shales. A number of similar ironstone nodules, some of large size, were noticed along the river bank on the South Branch. Their position there being probably due to ice transport. Clay iron-ore.

September 9th—Having engaged the services of John Gallion as guide, who was well acquainted with the road and the river between Edmonton and Rocky Mountain House, and leaving the rest of my party at Edmonton, I started with the buck-board and four horses, crossed the river at 1 p.m. and ascended the opposite bank. Striking nearly due south in about twelve miles we came to the crossing of White Mud Creek, a small stream which empties into the Saskatchewan about two and a-half miles above Edmonton. The trail we are now following is much better than that between Victoria and Edmonton. The general character of the country unchanged. A rich black soil; numerous swampy lakes, open richly grassed prairies with belts and patches of copse-wood with spruce and poplar trees. At 5.45 p.m. we camped on the open prairie on ground which had evidently not many hours before been occupied by a large Indian encampment. Most of the lodge poles were still standing, and we appropriated them for making our camp and for firewood. Made twenty-four miles. Start for Rocky Mountain House.

September 10th.—A good deal of rain has fallen during the night accompanied by thunder and lightning. Start at 6.30 a.m., thermometer 53°; barometer 27.10; fine and clear; passed by the west end of Long Lake and halted for dinner on the Peace Hill; (Musquachis or Bears Hill on Palliser's map;) distance by odometer from last night's camp 26.5 miles. At 5.30 p.m., we reached Battle River, crossed it, and camped near a belt of timber on the south of the trail, having travelled 30 miles since dinner. Battle River is here quite a shallow stream, 20 yards wide, with stony bed and gravelly banks about ten or fifteen feet high. From this point to its junction with the North Saskatchewan below Fort Pitt, its general course is nearly east through five and a-half degrees of longitude, and for a great part of the distance, according to Dr. Hector, it runs in a valley from 150 to 270 feet below the plain. No change in the character of the country, a drift covered surface the prevailing feature. Battle River

September 11th.—5.30 a.m., thermometer 40°; barometer 27.32; ground covered with snow. Start at 6.10 a.m., snow falling all the forenoon. At noon halt for dinner on Blindman's Creek, having travelled 33.4 miles. At the crossing place on Blindman's Creek, the rocks are well exposed in cliffs about fifty feet in height. Soft, friable, brown sandstone in beds of from one to ten feet thick with layers of thin bedded sandy shale, and, near the top of the section, a bed fourteen inches thick, of a hard, brown, flinty-looking rock. Externally many of the strata are Blindman's Creek.

white from a lime coating, as if whitewashed. Near the base, resting on sandstone, is a thin layer of lignite.

Friday, September 12th.—Barometer 27.00; thermometer 20° at 4 a.m.; a heavy white frost covering the ground, almost as thick as if from a fall of snow. Started at 6.50 a.m., and at 2 p.m. arrived at Rocky Mountain House, having travelled 37.4 miles. After crossing at 8 and 8.50 a.m. respectively, two small creeks, tributaries of Medicine River, Washing Creek and Lob-stick Creek, the latter thirteen miles from our last night's camp, the road—certainly the worst we have travelled over since leaving Fort Garry—enters a flat and rather thickly-timbered country, and for about ten miles its course is very crooked, skirting and crossing swampy meadows, muskegs, and belts of thick spruce forest. It then rises by a gentle ascent, passing through thick poplar and dwarf birch woods, to the summit of a ridge immediately beneath which, nearly 300 feet, and stretching away to the westward, lies the valley of the Saskatchewan. The view up the valley in this direction is bounded by the serrated ridges and snow-clad peaks of the Rocky Mountains, while in the foreground occasional glimpses of the river are afforded through openings in the forest, and on a broad flat on the left bank, and some two to three miles distant, the pallisades and roofs of the buildings may be perceived, which constitute the Hudson's Bay post of Rocky Mountain House; to reach, which, however, a considerable detour had yet to be made, as at the point where the road comes upon the valley the latter is bounded by perpendicular cliffs of sandstone, some 80 or 100 feet in height. Following along the brink of these cliffs in a southerly direction, a gradual descent of some two or three miles is made into the valley of Clearwater River, a large tributary which joins the Saskatchewan, about a mile below the post. The road to the post crosses Clearwater, about a quarter of a mile above the junction, and passing over the alluvial flats in the angle between the two rivers, strikes the Saskatchewan directly opposite the fort. Here the horses were relieved of their harness, and being driven into the stream, quickly reached the opposite shore, to which a batteau conveyed ourselves, baggage, and buck-board; and our land journey of 1,055 miles was completed, only to commence, however, on the following day another of still greater length by water.

Thickly wooded country.

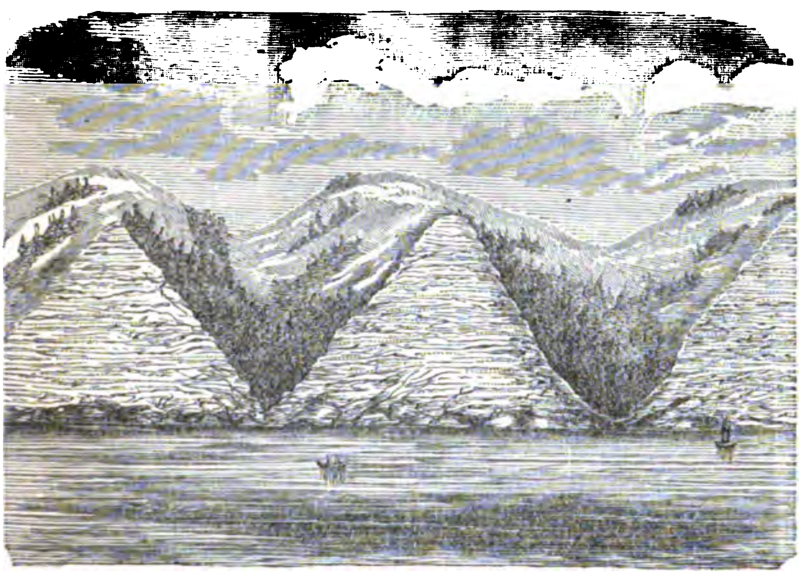
Clearwater River.

It will perhaps be unnecessary to give the journal of this homeward voyage in detail, and I shall, therefore, make only a few brief extracts from it, and conclude with some remarks on the geological and other features which were observed at the Mountain House and along the river, thence to Winnipeg.

September 13th.—Having made all necessary arrangements, and through the kindness of Mr. Fraser, the officer in charge, secured the only boat there was at the Mountain House, a half-sized Hudson Bay batteau, and

Departure from Mountain House.

also the services of a Half-Breed lad to assist Gallion in navigating it, at 1.30 p.m. we pushed off into the stream, and without the aid of oars, impelled by the current only, we floated down at the rate of four and a half or five miles an hour, and at 6.30 p.m. we camped on a narrow alluvial ledge, at the base of a sandstone cliff 120 feet in height; the following day, September 14th, starting at 5.30 a.m., we passed Baptiste and Brazeau River, and camped at 5 p.m. on a small island, about one mile below a series of remarkable looking cliffs, resembling a number of equal sized pyramids standing side by side; they are due to the action of the atmosphere scooping out hollows or small steep valleys in the soft sands and clays forming the banks. These valleys slope up at an angle of 20°–25° to the prairie level, while the intervening spaces present vertical sections of the strata, as shewn in the accompanying woodcut. Travelled 39 miles. Remarkable cliffs.



September 15th.—Started at 5.15 a.m. and camped at 5.45 p.m. To-day we passed two fine exposures of a thick seam of coal 18 to 20 feet, cropping in the right bank. A photograph was taken of the second exposure, see page 49; travelled 34 miles. Heavy rain on the 16th, commencing in the afternoon, compelled us to camp early. On the 17th at 1 p.m. we reached Edmonton. The total distance from the Mountain House to Edmonton as shewn by my sketch of the river is 138 miles, and Thick coal seam

I think there must be an error in Dr. Hector's estimate of it, which he gives at 212 miles. On the afternoon of the 18th, the interval having been spent in settling accounts and making arrangements for our further journey, we bid adieu to Edmonton. During my absence a boat had been built for us to descend the river in, but as she was only fastened with clenched iron nails and not strong, I decided to go on in the one I had brought from the Mountain House, a good staunch boat 25 feet in length and fastened with copper rivets. From Edmonton to Carlton, a distance by the river of about 400 miles, our party, with the exception of Macdonald who remained at Edmonton, was the same as on the journey over the plains from Fort Garry, five persons besides myself, and as none of us had ever before descended the river, we had to find our way as best we could through the dangers and difficulties of the navigation, consisting of intricate channels, sand banks, shoals and rapids, none of which are, however, of a very formidable nature. Four of the party worked at the oars, the fifth took the helm, and I acted as bowsman, and continued my sketch of the river, noting the bearings and distances of each bend and sketching it in my note book to scale as we went along. Below Edmonton the current is much less rapid, and there are long stretches where, to keep up an average speed of four miles an hour, constant pulling is required. Sometimes the prospect of a more direct course tempted us to leave the main channel, and in almost every instance we were landed on shoals or sand banks, obliging us to retrace our steps, at the expense of much laborious pulling and poling against the current. Notwithstanding these mishaps, however, we made a prosperous and tolerably rapid passage, reaching Carlton on the 30th of September, the thirteenth day after our departure from Edmonton, and thus averaging considerably more than thirty miles per day, the time we were actually travelling being only eleven and a half days. On the morning of the 24th of September the thermometer fell to 20°, and from that time till we reached Carlton we had very cold and unpleasant weather, snow, sleet or rain falling every day, and the thermometer seldom more than three or four degrees above the freezing point; 14° being the lowest, and 30° the highest reading. On arriving at Carlton we found that a full-sized Hudson's Bay batteau, well equipped, and manned with five experienced Half-breed and Indian voyageurs, had just arrived with "peices" i.e. goods, from Cumberland House and would be starting on the return voyage the following afternoon. I at once arranged with Mr. Clarke, the Hudson's Bay officer in charge at Carlton, to allow our party to proceed down the river in this boat; and the same boat, but with three changes of crew, subsequently carried us the whole way to Fort Garry, a distance by Lake Winnipeg and Red River of about 800 miles.

Leave Edmonton.

Arrive at Carlton.

1st October.—Left Carlton at 1.50 p.m. We had made only about

four miles when, somewhat to my surprise, at 3.5 p.m., our crew pulled in shore and informed me they were going to have dinner. We had of course dined before leaving and so had they; but there was no help for it; the captain, voyageur, and guide in a Hudson's Bay batteau is supreme, stops when he likes, goes on when he likes, and consults his own fancy in all the arrangements, and if you venture to remonstrate, or to suggest that two breakfasts and two dinners are not required, he is very apt to become sulky and you find yourself worse off than before. At 4.30, having then made about four miles more, they again landed, on a low willow-covered island, and informed me they did not intend going any further that day. This did not look very promising for progress, and I began to wish we had come on in our own boat. The next morning we were off at 5 a.m., but what with grounding on sand banks, and stopping first to kill, and not long after to cook and eat a beaver, our progress was not more rapid than yesterday, and by 4.30 p.m. we had according to my estimate only reached 31 miles from Carlton. Thermometer at noon in the shade 28°, freezing all day and ice forming in the river and along the shore.

Slow-progress.

3rd October.—Started at 5.30 a.m., thermometer 30°. At 8.30 a.m. we reached the Prince Albert Mission station, and Hudson's Bay Company's farm, 42 miles from Carlton by the river. There are several settlers established here, on a fine open flat of excellent soil about 20 feet above the river, with hills in the rear gently rising to the prairie level. The church, the parsonage, the Hudson's Bay establishment, and the settlers houses make quite a village extending between two and three miles along the right bank of the river. At 4.30 p.m. we camped at "The Red Cliff" about seven miles below Prince Albert. On the following morning, starting at 6.25 a.m., we reached the head of Coles Falls or Rapids at 9.15 a.m., and though we had a good breakfast at a little before six our crew went ashore, lighted a fire and spent an hour cooking and eating. At 12.45 we arrived at the South Branch, a short distance below the last of the Coles Rapids, and where in the angle formed by the two rivers stood the now deserted establishment of Captain Butler, of which a sketch, not a photograph, is given page 43 of his "Wild North Land." Here we halted for dinner, and our crew did not lose the opportunity for another meal. Starting again at 2 p.m. three hours and a-half brought us to Fort a la Corne, 105 miles from Carlton, and 55 miles from our last night's camp. Leaving Fort a la Corne on Monday, 6th of October, we reached Cumberland House, on Pine Island Lake, via Sturgeon River, at 2.20 on the 9th, the distance according to my estimate being 155 miles, the last 18 miles across Pine Island Lake on a course nearly due east magnetic from the mouth of Sturgeon River. Cumberland House is situated at the south-eastern end of Pine Island Lake, and

Prince Albert Farm and Mission.

Confluence of the two Saskatchewans.

Reach Cumberland House.

about four miles north of the Sakatchewan River, into which there are three outlets from the lake: Big Stone River, immediately in rear and west of the fort; Tearing River, about four miles to the eastward; and Fishing Weir Creek still further eastward, and on the canoe route via Sturgeon Lake to Beaver River. At 2.45 p.m. on the 10th of October we set sail from Cumberland, steering for the mouth of Tearing River, which we entered at 3.15. The general course of Tearing River is south-east magnetic; where it leaves the lake it is nearly half a mile wide with a strong current, but is cut up by numerous low islands, and the channels are obstructed by large boulders of limestone. The islands are covered with a thick growth of willows and reeds, and here and there clumps of poplar. In the spring the whole country is apparently flooded. The high water mark left on the trees and bushes is about two and a-half feet above the surface; now the water is from six to seven feet below the top of the banks, or from eight to ten feet lower than when in flood. At 5.30 p.m. we made fast to the bank, and as there was no dry ground we camped on board. Distance from Cumberland about 16 miles.

Leave Cumberland.

Starting the following morning at 5.45 a.m., ten minutes pulling brought us again into the Saskatchewan, and at 9.30 p.m. we arrived at The Pas, Hudson's Bay post and Missionary station, having made 40 miles, the last ten after dark. The country bordering the river is throughout low and flat, thickly wooded with poplar, willow, and alder, also some ash, maple, and spruce. The banks rarely rise more than six or eight feet above the water, and consist entirely of fine alluvial silt. Similar low swampy country extends to near the entrance to Cedar Lake, a further distance of about 55 miles. On Monday, the 13th October, we left The Pas, and at 5.30 p.m. on Tuesday we camped on a small island in Cedar Lake. The next day we passed through Cross Lake and at dark camped at the lower end of the Cross Lake Rapids. Flat lying strata of buff-coloured limestone form the banks along this part of the river, and a thin covering of drift soil, resting on it, supports a thick forest of small spruce.

The Pas.

Cross Lake Rapid.

16*th October*.—Started at 6.15 a.m., at 7—having stopped a short time to look at the wreck of the first Saskatchewan steamboat, which we here found lying on the bank some eight or ten feet above the water—we commenced the descent of the Grand Rapid, and in fifty minutes reached the Hudson's Bay post on the shores of Lake Winnipeg. Starting again at noon, and favoured by a strong fair wind, we rounded Cape Kitchenashi, and at 5.15 p.m. camped in a small sheltered cove on the south side of the cape. From this point to the mouth of Red River, a distance of about 220 miles, our voyage occupied seven days, or till the morning of Friday the 24th October, head wind having detained us only one whole day and three half days. On the 26th of October, we reached Winnipeg,

Wreck of the first Saskatchewan steamboat.

having travelled since we left it on the 25th of July, by land and water, 2,300 miles.

Geological Features

Rocky Mountain House to Winnepeg, by the River.

Starting from Rocky Mountain House, lat. 52° 20′ north and long. 115° 10′ west, the North Saskatchewan River runs in a general north-easterly direction till it reaches a point about 90 miles below Edmonton in lat. 54° 10′ north, long. 111° 30′ west; it then sweeps gradually round to the south-east, on which course it runs with many minor bends till it reaches "*The Elbow*," lat. 52° 20′ north, and long. 107° west. At this point, as the name implies, a sharp bend occurs, again giving it a general north-easterly course, which it maintains to Cumberland Lake where it a second time reaches the latitude of 54° north between the 101st and 103rd degrees of west longitude; thence a comparatively short south-easterly course of about 150 miles carries it to its mouth in Lake Winnipeg, while the three upper sections above described have a nearly equal length of about 300 miles each. As I spent only 24 hours at Rocky Mountain House, and a considerable part of this time was necessarily occupied in making arrangements for our voyage down the river, the observations I made there were very limited. The general character of the vicinity, however, is so well and accurately described by Dr. Hector, that I can not do better than reproduce here his description, adding the few additional facts which came under my notice.

Under date January 14th, 1858, Dr. Hector says, "Crossing several large muskeg lakes, and then passing through a belt of heavy timber, we reached the Saskatchewan an hour before sunset, descending to it by a rugged gulley that led down the side of a sandstone precipice. We followed up the river about two miles upon beautiful clear ice, but which is full of open holes from the rapidity of the current, at one of which, caused by a rapid, we had to leave the river and pass through the woods, when we emerged in a large plain on which stood the fort. Extract from Dr. Hector's Report.

15th January.—After breakfast set off to a hill about two miles to the west in order to get a view of the mountains. After passing into the woods behind the fort the trail led through a large frozen "muskeg," in which was a heavy growth of spruce and larch. The terrace level on which the fort stands is twenty feet above the river, and in proceeding back a slight descent is made to the "muskegs" which lie along the base of the second terrace, like the first, composed of shingle made up of fragments of quartzite, gneiss, and of a deep blue and also light fawn-coloured limestone. This second terrace is covered with pines, and being free from underwood, presents a fine open glade, easily passed through; quite a contrast to the woods of spruce, which are almost impenetrable. On reaching the hill I found it to rise about eighty feet above the second

Character of the country around the Mountain House.

terrace level, and nearly 150 feet above the river, and as the timber had been all burnt from its surface, it afforded a commanding view. The surrounding country presented a rolling irregular surface, everywhere densely clothed with dark green pine forest, and having the south-west horizon bounded by the abrupt and bold outline of the Rocky Mountains. In front of the main range, that seemed to be about forty-five miles distant, there is a lower but well marked range which is wooded to the top, and only about twenty-five miles off. The point where the Saskatchewan cuts through the near range is due west from this, and is much further distant, owing to the north-west trend of the mountains. Three hundred yards below the fort there is a rapid in the river channel, and a fall of three feet caused by ledges of greenish sandstone that cross the stream. A few hundred yards below this the river receives a large tributary called Clearwater River, on the banks of which, as well as on those of the main stream, high sections of the strata are exposed. At the height of sixty feet above the stream beds of shingle, gravel and sand occur, overlying all the other beds, and clearly forming the remains of a fresh water deposit similar to the terraces which occupy the valley of the river. The layers of pure sand which occur in this deposit contain fragments of the stems of sedge-like plants. The irregularities in the denuded surface of the underlying beds often form deep depressions like the pot-holes found in the chalk, and which are filled by the shingle deposit.

Judging from the mineral composition alone there are three groups of beds exposed in the sections in this neighbourhood. 1st, massive cliffs of coarse-grained sandstone, composed of angular grains of quartz cemented by calcareous matter in small quantity. Just below the ravine where the Edmonton track comes down on the river there is a cliff of the sandstone 90 feet in height. The lines of stratification are very obscure in this deposit, being confused by joints and false bedding.

Sandstone cliffs.

2nd.—The next group is that exposed at the rapid, and is composed of a green argillaceous sandstone which, by weathering, always gives rise to sloping banks from which concretionary masses protrude. These beds are generally horizontal, but sometimes have a rapid dip. They seem to pass into the last group, and sometimes to fill depressions in it.

3rd.—This consists, first, of ten to twelve feet of hard blue shale, with ironstone bands and concretions. Under this shale lies a bed of soft argillacecus sandstone, with concretions somewhat resembling the 2nd group. Under this bed is found the lignite, with shales, and (except close to it where these shales are carbonaceous) their colour is of a light greenish-grey. In the shales are found plant-impressions, among which is the Taxites. At some points there are two beds of coal, but they are very variable and local. The lignite found here is better adapted for fuel than that obtained at Edmonton.

Fossil plants.

16th January.—I started up Clearwater River, travelling on the ice

for about twelve miles. The banks of the river were high and steep, and present sections of the argillaceous sandstones, sometimes forming very picturesque and ruinous cliffs which peep out from among the dark green pines. The timber is good everywhere, but never of large size. On the high grounds I observed here what I think must be the *Pinus resinosa*, although all the pines are termed by the Company's servants le Cyprés, which, however, is more properly the *P. Banksiana*. The tree which I suppose to be the *P. resinosa* I have never seen lower down the Saskatchewan. It rises with a beautiful straight trunk with light branches to the height of 70 feet, its trunk being often 16 inches in diameter and finely tapered like a mast. The cones and foliage are somewhat like another pine which grows abundantly on the shingle terraces. This tree answers nearly to the *P. inops*, or New Jersey Scrub Pine, but it presents a more sturdy habit and several other peculiar characters. It is the same that was noticed near Carlton, but from that point it was not again seen along the Saskatchewan till after leaving Fort Edmonton, and never in any quantity till near the Mountain House. It seems to grow only on loose sandy soil and prefers the surface of the terraces. Besides these pines I observed here, for the first time since leaving the canoe route, the silver spruce, *Abies balsamea* or Le Sapine of the voyageurs, with its beautiful foliage, dark green above and silver below. It is not a common tree here, however, the mass of the forest being still made up of the white spruce, canoe birch, and poplars, along with the pines before mentioned. Timber trees.

17*th January*.—To-day I travelled up the Saskatchewan River for about eight miles. The river opposite the fort is 130 yards wide, and when it is lowest from two to three feet deep. At every bend fine sections were exposed of the lignite group. The river seems to be winding about in what had been an immense valley cut through these strata and then filled up with beds of shingle which had again been scooped out and formed into terraces, and finally the present river valley had been formed cutting through not only these terraces but also the underlying strata in some cases. Thus the shingle terrace facing the bank of the river is seen to inclose patches of the lignite shales, in which have been worn deep furrows prior to the deposit of the shingle. Some sections shew the remarkable manner in which the passage takes place in the mineral structure of the bed. On the left bank of the river we have the bank 80 feet high, and consisting of:— Fine sections of the lignite group.

Sections near Rocky Mountain House

Drift with boulders.
Shingle.
Iron shales.
Lignite, a few inches.
Indurated shales.
Lignite, a few inches.
Sandy clay.

Lignite variable.
Indurated shale (Taxites).
Lignite, one foot.
Ironstone shale.
Lignite, very irregular, but compact.
Concretionary sandstone, thick bedded.
River level.

Shales and sandstones.

Two hundred yards below this, in the same cliff, nothing but hard blue shales are exposed, and fifty yards further on these pass into the soft concretionary sandstone, and then again into the mixed beds. There are a few dislocations in the strata, but these do not affect the beds more than a few feet. Six miles above the fort the banks are again formed of high cliffs of the coarse-grained sandstone, group 1, after which they are again low, and the surrounding country is flat."

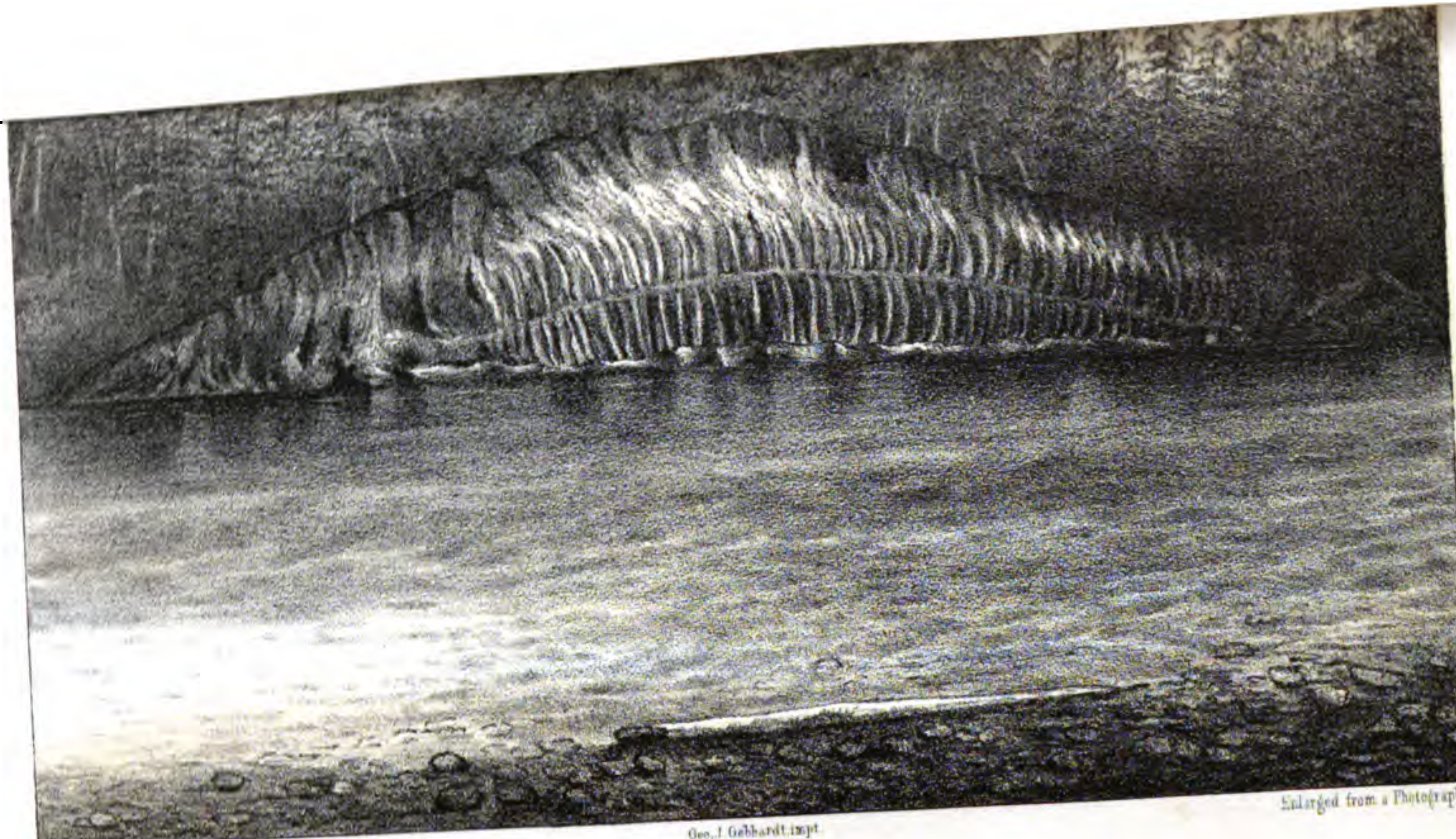
Immediately above the fort the river bank is about forty feet in height and exposes the following section : —"

	Feet.	Inches.
Soil	3-4	0
Coarse rounded gravel	10	0
Grey shale	15	0
Lignite coal	0	3
Parting shale, carbonaceous	0	2
Lignite coal	0	10
Shale	7-8	0
Sandstone, olive green, soft and friable	3	0
Dark grey indurated shales to water level	41	3

Three-feet coal seam.

I was not successful in finding any fossils *in situ* in the coal strata at Rocky Mountain House, with the exception of a few fragmentary plant remains, too indistinct for determination. At about a mile and a half below the mouth of Clearwater, on the left bank, a seam of excellent coal crops out, said to be from two to three feet thick. It is only accessible at low water, and I did not see it. A considerable quantity of coal has been raised from it for use in the forge at the fort, for which purpose it is found to answer well. It is a hard bright jet-like coal, and does not split up on exposure like that from most of the other beds in the vicinity. No. 1, in the appended analyses by Dr. Harrington, is of a sample of this coal. The other samples of which analyses are given are all from seams which crop in the banks of the river, between Rocky Mountain House and Edmonton, and these analyses serve to show that the lignite coals of the Upper Saskatchewan are very superior to those met with farther to the south, along the boundary line, and in the Qu'Appelle Valley. The latter appear to be all of Tertiary age; whether the Saskatchewan coals are of the same age, or Cretaceous, is at present uncertain. The plant remains in both are alike, as well as the lithological character of the associated sandstones, shales and ironstones, but no animal remains have yet been found in the strata associated with the Saskatchewan seams. Dr. Hector says, "As developed at the Mountain House the formation,

Age of the coal rocks.



A.H. Foord del. et lith.

Geo. J. Gebhardt, impt.

Enlarged from a Photograph.

VIEW OF EIGHTEEN-FEET COAL SEAM

North Saskatchewan River

whatever its exact age, may be described as consisting of sand and clay in varying proportions; great ridges of pure sandstone, including basins, in which have been deposited clays and clay sandstones charged with lignites and ironstone in large quantities."

In sections exposed on Red Deer River, but in beds considerably above the lignite and silicified wood layers, Dr. Hector found *Paludina*, *Ostrea* and *Natica*. From the Mountain House to Edmonton, and thence to a short distance below Victoria, there are fair exposures of the strata at comparatively short intervals along the river; soft friable green, grey and brown concretionary sandstones, alternating with blue and grey arenaceous and argillaceous shales, with layers and beds of lignite, and bright jet-like brown coal, are the prevailing features in these exposures. In the shales there are layers of nodular clay iron-ore, holding numerous fragments of plants, and containing an average of 34·98 per cent. of iron, but I did not see these anywhere in sufficient abundance to be of economic importance. At one place on the right bank of the river as mentioned page 41, about forty miles below the confluence of the Brazeau River, I found a seam of this jet-like coal, which measured from 18 to 20 feet thick. It occurred of equal thickness in two exposures rather more than four miles apart. In the first exposure, which extends some 50 or 60 yards in length, but which, owing to the swiftness of the current running at its base, is not easily examined, the seam is almost flat, and rises from the water in a nearly vertical cliff, exposing eighteen feet of apparently excellent coal. The bottom of the seam here was beneath the water, and could not be examined; above it the cliff was not accessible, and the rocks were concealed by slides of earth and other debris. The second exposure, which is no doubt on the continuation of the same seam, occurs in an arched form, and shows eighteen feet of coal, with one, two to three inch parting of shale. The accompanying sketch, drawn by Mr. Foord, is from a photograph of this exposure. The specimens of the seam which I collected, were all taken from the surface, and it is not unlikely that beyond the influence of atmospheric action the coal will prove of better quality than is indicated by these specimens. In the accompanying analyses (see appendix) Nos. 2, 3, and 4 are of samples from the eighteen feet seam. At intervals, the whole distance from Rocky Mountain House to Edmonton, 135 miles, and thence to Victoria, 76 miles further along the course of the river, similar rocks with coal seams and nodular ironstone layers, were observed.

Red Deer River.

Clay iron-ore.

20 feet seam of coal.

Analyses of coal.

Dr. Hector has separated the Edmonton coal rocks from those in the vicinity of the Mountain House by an intervening area which he considered to be occupied by a somewhat higher section or division of the Cretaceous series. He did not apparently see the thick seam of coal which I found, as above stated, below the Brazeau River, about eighty-

Five feet six inch coal seam.

six miles from Rocky Mountain House; and another seam of five feet six inches thick, which I found at a point some fifteen miles higher up the river, as well as the numerous indications of seams which occur between the out-crop of the eighteen feet seam and Edmonton, probably also escaped his notice, as he travelled partly during the night, and in the winter, on the ice, when many of the exposures along the banks must have been concealed by snow. The observations which I was able to make descending the river do not enable me to say whether the seams retain their thicknesses or are connected for long distances, or whether the very numerous exposures and indications seen in the cliff sections represent only more or less lenticular shaped and isolated patches, repeated at different horizons and over large areas. Dr. Hector appears to incline to the latter idea, and, in a note referring to the seams at Rocky Mountain House, he states, "The coal beds are not continuous for long distances." Whether this is actually the case or not, there can be no question that in the region west of Edmonton, bounded on the north by the Arthabasca River and on the south by the Red Deer River, there exists a vast coal field covering an area of not less than 25,000 square miles: and beneath a large portion of this area we may expect to find workable seams of coal at depths seldom exceeding 300 feet, and often, as in the case of the thick seams above described, very favourably situated for working by levels from the surface.

Extent of the coal field.

Below Victoria the river valley widens considerably, and often rises by successive broad steps or broken terraces to the level of the prairies on either side. Sometimes as in the vicinity of the St. Paul R. C. Mission station, 97 miles below Edmonton, these terraces are very regular and quite bare, while at others they are thickly clothed with brushwood of willows, alder, and other shrubs mixed with poplar trees, and here and there a small clump of spruces or pines. Occasionally the banks abut steeply on the river, and afford imperfect exposures of the strata, which differ considerably from those met with at and above Victoria. Hard flaggy sandstones and impure limestones, associated with soft blue and grey clay shales, with layers of large concretionary, olive-brown, cement-stones or septaria, seamed with veins of yellowish-white calc-spar, and holding fossil shells (*Inoceramus*, &c.), are here met with, but no thick bedded sandstones, and without associated coal or lignite beds, or, so far as I observed, any plant remains. Whether these marine Cretaceous beds are above or below the Edmonton coal-bearing beds I am at present unable to say. I am, however, disposed to take the former view, notwithstanding that the plant remains associated with the coal beds are of modern types. Respecting the few specimens of these which were collected, Dr. Dawson has kindly furnished the following note:—

Fossiliferous limestones.

Geological position of the Edmonton coal beds.

1 a. is a species of Taxus very near to Taxus baccata in the structure of the wood. Note by Dr. Dawson on fossil plants.

3 c. *Cupressoxylon,* type of Thuja or Cupressus. Like No. 3 of Mr. Bell's collection.

4 d. Coniferous wood, obscure, probably some species of taxine tree.

2 a. Mineral charcoal from brown coal of Edmonton. This is Coniferous, Cypress or Thuja, and not unlike 3 c. It may be the wood of a tree allied to the American cedar.

All the above are modern American types of wood, and may probably be Tertiary.

Dr. Hector divided the Cretaceous strata of the prairies into an upper, middle and lower group, and in the latter he placed the Rocky Mountain House and Edmonton coal series, at the same time remarking: "In my next and lowest group I have (with great hesitation) classed the large deposits of coal or lignite of the prairie country, that are sufficiently compact to be of value as fuel, but which have hitherto been generally classed as of Tertiary age."

There is no doubt that in British Columbia, as shown by Mr. Richardson in his last report—(Report of Progress, 1862-63,) the coal seams belong to the lower part of the Cretaceous series and are overlaid by more than 4,000 feet of strata holding *Inocerami*, *Ammonites*, *Baculites* and other marine Cretaceous fossils.

Should there prove to be a similar arrangement of the formations in the Saskatchewan Valley it would very greatly enlarge the area over which workable seams of coal may be expected to occur. The boring at Rat Creek now in progress, together with those proposed to be made at Fort Pelly, Carlton and Victoria, will probably settle this very important question. In the vicinity of Fort Pitt and thence, wherever sections occur, the whole distance to the Elbow, similar Cretaceous clays with Septarian nodules are seen.

At the Elbow the river leaves the eastern limit of the third or uppermost prairie level formed by the Eagle Hills on the south side, and by the Thickwood Hills on the north side of the valley, and making a sharp bend to the north-east more or less parallel with the trend of the eastern slopes of the hills named, it flows across the second prairie level, making for the nearest point of its eastern limit, which it reaches about forty-five miles below Fort à la Corne. Between the Elbow and this point, and especially below Carlton, the immediate banks of the river are either low and flat, or rise in well wooded slopes, broken into more or less rounded hills and ridges, or shewing a succession of terraces, to the prairie level, some 200 or 300 feet above the river. The Elbow to Fort à la Corne.

In a few places, especially at Cole's Falls, and for short distances both above and below Fort à la Corne, the valley closes in and high cliffs rise Coles Falls.

steeply from the waters edge nearly to the prairie level. They are, however, all of drift, consisting of gravel underlaid by sand and clay in which there are occasionally seen one or two layers of imbedded boulders of Silurian limestone, gneiss and dioritic, probably Huronian rocks. The average level of the plains here above the river, and at some distance back, does not probably exceed 300 feet. After leaving the eastern limit of the second prairie level the river banks rarely rise to an elevation of fifty feet above the water, and the adjacent country is everywhere low and swampy and scarcely elevated at all above the flood level of the river, the marks of which were occasionally observed on the trees and bushes some eighteen inches or two feet above the surface, which consists of a deep, rich alluvial silt of a greenish-grey colour, a mixture of fine sand and clay. Similar low swampy country everywhere intersected by water channels extends with but few intervals to Cedar Lake, at the entrance to which ledges of buff-coloured Silurian or Devonian limestones first make their appearance. They are, however, in all probability, close beneath the surface over the whole of the great alluvial delta of the Saskatchewan which may be said to extend from Cedar Lake for a distance of 160 miles westward to the base of the hills marking the eastern limit of the second prairie level which, as already stated, crosses the river about forty-five miles below Fort a la Corne. Sir John Richardson says that the Silurian strata are again seen in Beaver Lake immediately north of Pine Island or Cumberland Lake, and again at the Methy Portage and along the valley of Beaver River, which is about ninety miles north-westerly from Carlton. At the Methy Portage they are overlaid by bituminous shale, the age of which has not been ascertained.

Swampy country.

Silurian and Devonian rocks.

Cedar Lake to Lake Winnipeg.

From Cedar Lake to the mouth of the Saskatchewan in Lake Winnipeg, these Silurian rocks are either at the surface or only very thinly covered by soil or drift. They are well exposed in vertical cliffs at the Grand Rapids, and they likewise, as I have already stated, occupy much of the western shores and many of the islands in Lake Winnipeg, and extend 350 miles south-easterly to Fort Garry. Some of the beds would I think afford good slabs for lithographic purposes, as well as inexhaustible supplies of excellent building stone, while from others a rich harvest of fossils awaits the collector.

Extract from Mr. Hind's report.

On the shores and islands of Lakes Winnipegosis and Manitoba, somewhat similar buff-coloured limestones holding Devonian fossils are described by Professor Hind. He says, "At Flat Rock Bay, limestone of Devonian age is seen on the south side. Some of the layers are highly fossiliferous and hold numbers of *Atrypa reticularis* and *A. asperis*. The stems of crinoids are common but the species are very few. The rock is nearly horizontal and the general dip south-west at a very small angle, but many slight undulations occur giving an inclination of equal extent in

an opposite direction. The exposure in the bay is ten feet high worn into caves. The colour is a pale buff with some reddish-brown layers. Fucoids are abundant and become when weathered yellowish-buff."......" The rock exposures on Snake Island are very interesting, not only on account of the fossils they contain, but in consequence of the evidence they afford of a slight upheaval so rare in the present disposition of the rocks of this region.

" The exposure at its highest point does not exceed twenty feet, but it is the centre of a low, narrow anticlinal running north and south nearly. The dip on the east side is S. 75° E. $<$ 18°; and on the west W. 20° S. $<$ 5°. The limestone is highly fossiliferous, beautifully stratified, very hard and bituminous. It holds abundance of *Atrypa reticularis*, *Tellina ovata*, and fossils belonging to the genera *Euomphalus*, *Productus*, *Gomphoceras*, *Orthoceras*, *Lituites*, with trilobites, crinoids, &c. Mr. Billings thinks this locality unquestionably Devonian." Fossils.

We have then in this great low-lying region constituting the first prairie level, the greater part of which is occupied by the waters of Lakes Winnipeg,—Winnipegosis and Manitoba, and by the vast delta of the Saskatchewan,—rising from beneath the Cretaceous rocks, the eastern out-crops of an extensive series of beds of Devonian and Silurian age, and it becomes an interesting question to determine how these eastern palæozoic strata are related to those of more disturbed and altered aspect which 1,000 miles to the west, rise from beneath similar Cretaceous coal-bearing formations at the sources of the Saskatchewan, and there form the eastern slopes and, I believe, many of the higher summits of the Rocky Mountains. We know at present little or nothing respecting the total thickness of this thousand miles of Cretaceous rocks; neither do we yet know to what extent the marine beds which occupy the surface beneath the drift, from the 100th meridian westward to about the 112th, may be underlaid by the supposed older fresh water deposits, with their associated seams of brown coal and iron ore. Relations of the eastern and western palæozoic formations.

The general scarcity and the poor quality of the timber over hundreds of miles of country bordering the two Saskatchewans render it, however, a matter of the very greatest importance in connection with the future settlement of a large portion of the "Fertile Belt," and with the opening it up either by land or water steam transport to ascertain where and at what depth beneath the surface coal could be procured which would be available for domestic purposes, as well as for the supply of railroads and steamboats. The almost universal covering of superficial deposits, already mentioned, the general flatness of the strata, and the comparatively few points where they can be observed in natural exposures, renders mere surface examination of but little avail in solving this question, and to determine it borings will have to be made along the valley of the river between Carlton, Pitt and Edmonton.

Considering how little definite information we at present have respecting our own great western coal-fields it may be interesting and useful to give here some extracts from the report of the late Professor James T. Hodge, on the coal mines of the Rocky Mountains, in Colorado, Utah, and Wyoming. The more so, as the coal seams which are now being largely worked in these mines undoubtedly belong to what may be regarded as only the southern prolongation of one vast and wide-spread coal bearing formation extending, with but few interruptions and with wonderful uniformity of character, from the shores of the Arctic ocean for thousands of miles along the eastern slopes of the Rocky Mountains: and there is consequently every reason to anticipate that Professor Hodge's observations and remarks will be, in all important points, as applicable to the coal seams in the British portion of the region as they are to those in the United States Territories above named. And, so far as they have yet been investigated, this is found to be the case.

Extracts from Professor Hodge's report.

Professor Hodge says: "All these coal mines are found in a series of sandstones and fire-clay probably of Lower Tertiary age.* No limestones occur with these strata, and black slate is met with in small quantity only. The sandstones are generally somewhat friable in texture, and are often exposed in bold cliffs the faces of which have weathered in very irregular shapes, and frequently present deep holes and cavernous depressions. Its colour is from a light yellowish to reddish-brown, and sometimes grey. In places it is sufficiently sound and firm to make a good building stone. The fossils it contains are chiefly leaves of deciduous trees. No ferns and other fossil plants are found in the formation like those common to the true coal measures. The black slates forming the roof of a coal bed at one locality in Wyoming Territory are found filled with fossil unios, which, as the writer is informed by Dr. J. S. Newberry, are probably an undescribed species.

Fire-clay and iron-ore.

Fire-clay is perhaps the predominant material of the formation. It occurs in beds of great thickness, especially in Colorado, the summits and sides of some of the hills near the coal mines are partially covered with masses of brown iron-ore that have the appearance of solid ledges, but which were no doubt collections of clay iron-stone, left behind when the lighter materials of the strata containing them were removed, and converted subsequently by atmospheric agency into those brown hydrates.

Thick coal seams.

"The coal beds are often of great size, the largest now worked being 26 or 27 feet thick. This is on Bear River on the eastern border of Utah. For the most part they are remarkably free from impurities, it being not rare to see a face of eight or even ten feet of clean coal of brilliant

* By Dr. Hayden's report of 1871, they appear to be Cretaceous or a transition series between the Cretaceous and Tertiary.

lustre, perfectly sound and solid in the mine, without a particle of slate or any visible foreign matter that would injure it. Iron pyrites, however, may generally be detected in small flakes, and thin disks but very rarely in sufficient quantity to be injurious. Mineral resin is a common ingredient of the Colorado coals, and was met with at one of the mines only on the Union Pacific Railroad, that at Carbon. The beds lie on an angle with the horizon, some are vertical, none were observed level. All the coals crumble soon after being exposed to the weather, but when protected they remain a long time unchanged as is shewn by a large lump in the possession of the writer, which he obtained at a mine in Boulder County, Colorado, in 1863, and which is still sound. This tendency to crumble is the cause of great waste at the mines, all the greater, that these Tertiary coals can scarcely ever be made to melt and agglutinate into a firm coke. With rare exceptions when submitted to the coking process they retain their form, or crumble into a dry powder. As seen by their analysis, they all contain water in their composition; and this is very slowly given up even at the boiling temperature. Its presence necessarily detracts from the calorific power of the coals, not merely by reason of the water taking the place of so much carbon, but by the consumption of more to produce the heat required to expel this water. Hence it is difficult to obtain a strong concentrated heat, such as is needed for welding iron in the forge-fire, and it is only by particular care and skill that the blacksmiths have generally succeeded in making it answer their purposes. At the machine shops of the Union Pacific Railroad, it is not yet admitted as a substitute for eastern bituminous coal, though some of these are brought from Pennsylvania mines about 2,000 miles distant, and the very best of the Rocky Mountain coals are obtained directly on the line of the railroad. As a fuel for locomotives and for domestic purposes, including cooking as well as warming, the coal in general, answers very well. It kindles and burns freely, making a bright fire with a yellow blaze and comparatively little smoke. The odor of this is not so strong or disagreeable as that of the bituminous coals, and somewhat resembles the smell of burning peat. The smoke is not always dark and thick, but is sometimes of light grey colour. The ashes are remarkably light and bulky. The engineers of the locomotives find that some varieties crumble more than others in the fire and sift through the grate bars. These require closer screens at the top of the smoke-stacks. They endeavour to obtain the coal as freshly mined as possible on account of its sounder condition. Clinkers sometimes form sufficiently to be troublesome, when the coals are obtained from those mines that contain seams of slate. There have been a few cases of combustion of refuse heaps of coal, supposed to have occurred spontaneously. The presence of iron pyrites in coals so easy to crumble and ignite as these, cannot fail to suggest this danger, and the

Mineral resin.

Character of the coals of Colorado.

Ashes.

Iron pyrites.

importance of guarding all heaps of it from becoming wet. It is not unusual in the Rocky Mountain region to meet among the strata of sandstones, beds of ashes, which are evidently the ruins of coal-beds, some of which are of large size. The writer has seen many such on the banks of the upper part of the Missouri River.

" The Geological position of these coals together with the considerable proportion of water in their composition, places them in the class of brown coals, or lignites which are for the most part distinguished by their fibrous structure and close resemblance to the wood from which they are derived. Other varieties are met with in various conditions of change, and among them some that closely resemble the ordinary bituminous coals in their compact texture, brilliant lustre, and black color both of the coal and its powder, thus differing entirely in appearance from the brown coals or lignites that give a name to the class. This is the general character of the coals of the Rocky Mountains, and their composition shows they are far superior in quality to what the name of the class would indicate. In deed they appear to be better than the best of the foreign coals of their own variety ; and as they present a wonderful degree of uniformity over extensive territories, it seems they are really entitled to an appropriate name that should distinguish them not merely from the common bituminous coals, but from the lignites also, to which they bear still less resemblance."

In commenting upon Professor Hodge's report, Professor J. P. Lesley remarks, " We can only invite attention to a few of its statements :

Remarks by Professor Lesley.

" 1. To the notable percentage of water in the coals as shewn in the table of analyses.

" 2. To the vertical posture of the beds along the western margin of the field. This shows that the whole Missouri, Platte, Arkansas River basin country has slipped down eastward upon its foundation, the underground slope of the Rocky Mountains ; a phenomenon of the Alps as described by the Austrian Imperial Geological Surveyors, and of the Himalayas as described by the Geologists of the British Indian Survey ; a phenomenon repeated along the eastern margin of the Cumberland Mountain bituminous coal field in Western Virginia, where the fall back has been westward off the underground rock slope of the Blue Ridges formation, and the horizontal coal measures are suddenly turned up vertically at a right angle for hundreds of miles in length, and only a mile or two in width.

" 3. To the evidences of fresh water deposition of these western coals and also of their shore deposition ; and as a consequence of this last, of their great irregularities in thickness, a 14-foot bed thinning, in a short drift, down to eight feet and even to a few inches ; making the most scientific mining necessary, and offering a serious warning to the people of those States that they must hoard what they have with all their skill and care.

Mr. Hodge's strictures upon the shocking and wicked waste going on in the magnificent 26 foot bed of the Evanston mines in Utah would, under any foreign government, call out immediate preventive legislation.

"4. To the fact that, as in the case of the Golden Range, Clear Creek coal beds, a most discouraging and in fact almost invisible out-crop may conceal at a depth of 50 or 100 feet a bed of coal ten feet or more in thickness.

"5. To the wonderful solidity and uniformity of some of these beds, (once despised as lignites), their astonishing clearness and freedom from slate seams and ashy ingredients, and their portability on railroads, as in the case of the Marshall coal.

"6. To the real value of coal-measure iron ores, once carbonates, now hematites; once locked up in clay strata, now released and covering the ground." Value of the iron-ores.

The foregoing extracts are taken from McFarlane's "Coal Regions of America."

DRIFT.

In connection with the distribution of the mateiials forming the drift some noteworthy facts were observed. Blocks and often enormous rock masses of the buff or cream coloured Silurian limestone holding characteristic fossils are widely and abundantly distributed over the first and second prairie steppes. The ascent to the third prairie level, which has an average elevation of from 1,900 to 2,000 feet above the sea, commences at the Thickwood Hills, twenty miles west of Carlton, and on it the limestone boulders do not appear to have reached further west than the longitude of Fort Pitt, and between Pitt and Edmonton not a single boulder of limestone was observed, either along the Saskatchewan River or on the plains. On the river, above the confluence of the Brazeau —a large tributary coming in from the west about midway between the Mountain House and Edmonton—there are no boulders and very few pebbles of granite, gneiss or mica schist. At the Mountain House, the pebbles and boulders in the drift which is there seen in contact with the coal-bearing rocks as well as those seen along the river bed are nearly all of either coal measure sandstone or conglomerate, or of varieties of hard quartzose rocks, and though I searched carefully, I did not succeed in finding any of a granitoid or gneissic character. Small pebbles of grey and whitey-brown limestone holding fossils, but too fragmentary for determination, were also observed, but by far the larger proportion of the pebbles and boulders in the river at Rocky Mountain House are composed of the hard siliceous rocks, and many of them are traversed by cylindrical forms, having all the appearance of the *Scolithus*, of the Potsdam sandstone formation. It may further be stated that

Distribution of boulders.

Potsdam sandstone.

along with the disappearance in ascending the river of the boulders of granitic, gneissic and other crystalline rocks, the auriferous character of the drifts likewise dies out; and I was credibly informed that no gold could be found on the North Saskatchewan above Rocky Mountain House, though it had frequently been prospected for by experienced miners. The first gold washings which we saw in descending the river were rather more than forty miles below the mouth of the Brazeau; and thence to Edmonton, and for some miles further down, more or less gold has been found on the bars and in the river banks, but always in a very finely divided state, shewing evidence of having been transported from afar. Even as low down as Carlton, gold can I believe be found, though not in quantities sufficient to pay for working. On the South Saskatchewan, at the crossing place, about twenty miles south-east of Carlton, I washed out a few minute specks of gold from the gravel in the bed of the river, small red garnets with a considerable quantity of magnetic iron sand constituting the bulk of the residue in the pannings. It would thus appear that the gold of the Saskatchewan has not been derived from the mountains at its source, but from the drifts composed of granitoid gneiss, with hornblendic and micaceous schist, quartz and limestone, which are spread over the face of the country for hundreds of miles and which must have been themselves largely derived from the denudation of the great belt of Laurentian and other crystalline rocks which extends from the shores of Lake Superior north-westerly to the Artic sea.

Gold on the North Saskatchewan.

Garnets and magnetic iron sand.

Origin of the gold.

WEATHER, SOIL, TIMBER, ETC.

During the whole journey, we were favoured with remarkably fine weather. On the outward trip, we were detained only one whole day by rain, and half a day from the same cause, on the homeward trip. We had a few wet nights, and snow fell on two or three days between the 11th and 30th of September. The first frost was experienced on the 4th of September, when the thermometer at 4 a.m., registered 28° Farenheit. On the 6th, at 6 a.m., it registered 26°. The next frost occurred on the 11th of September, the thermometer falling during the night to 20°; and on the 23rd September, the thermometer registered during the night twelve degrees of frost. Thenceforward frosty nights were of pretty frequent occurrence, and on the 29th of October, the steamboats on the Red river were all frozen in. These, as I was informed, unusually early frosts, injured many if not all of the wheat crops on the Upper Saskatchewan, and also some of the potatoes that were still in the ground.

Early frost.

The drying up of the country already alluded to page 27 has been ascribed to various causes, but is generally supposed to be connected with the gradual destruction of the forests over large areas, by fire, diminishing

Effects of prairie fires.

the rain fall. Whatever the effect may be of these destructive conflagrations, in reference to the water supply of the region, there is no doubt that at different times almost every square mile of the country between Red River and the Rocky Mountains has been subjected to them; and that hundreds of miles of forest have thus been converted into wide and almost treeless expanses of prairie. After leaving the valley of the Assinneboine, the second and third prairie steppes, on the route we travelled from Fort Ellice to Rocky Mountain House, may be said to be entirely denuded of good timber. Between the Assinneboine and the English River 120 miles west of Carlton, or for a total distance of 400 miles neither oak, ash, elm, birch, pine or spruce trees were seen, and even the poplar are of small size, and suited for little else than firewood. Around the Little Touchwood Hills Fort there is a small extent of forest in which the largest poplar trees attain a diameter of two feet, and in the same district there are also some fair-sized white birch trees. On the English River and thence westward, both along the banks of the Saskatchewan and of the northern tributaries, spruce, pine and tamarack of small size are tolorably abundant. Along the river, above Edmonton, large spruce timber is plentiful, and is annually cut in considerable quantities and floated down the river, for the supply of the posts and settlements below, as far as Carlton. At about twenty miles below Carlton, and thence to Lake Winnipeg, the river passes through the more thickly wooded region, and spruce, pine, birch and tamarack are largely intermixed with the poplar which still forms the bulk of the forest. Scarcity of good timber.

The greatest extent of uniformly rich soil in all this vast region is certainly to be found on the first prairie steppe. Its lesser elevation, probably in no part exceeding 800 feet above sea level, renders it still more favourable for the cultivation of wheat and of other products liable to injury from the spring and autumn frosts which are prevalent on the more elevated plains. The general luxuriance of the vegetation, however, both on the second and third prairie levels over many hundreds of miles, at heights varying from 1,500 to upwards of 3,000 feet, amply testifies to the exceeding richness and fertility of the soil. Even on the hills and ridges where for the most part somewhat lighter and shallower soil prevails, and which might not be well suited for cultivation, there is with few exceptions an abundant growth of the most nutritious grasses and herbs, on which all kinds of cattle thrive admirably; while in low lying flats and swamp beds an abundant supply of the finest hay can readily be secured for winter fodder in case of need. At present, there are comparatively few cattle in the country, and it is customary to house and feed them on hay during the winter, the prevailing opinion being that they can not otherwise survive. There is, however, every reason to believe that this a mistake; and that if a hardy race of cattle, suitable to the climate, were Character of the soil. Wintering cattle.

Introduction of cattle.

introduced, they would speedily become acclimated, and not only be able to survive, but would thrive through the winter without the aid of artificial feeding and shelter; and if so vast herds might soon be reared on these rich and boundless pastures, reanimating the now deserted feeding grounds of the buffalo, and becoming a source of large profit to the settler, as well as affording a ready and cheap means of providing for the Indians who are now frequently reduced to the verge of starvation, owing to the annually increasing scarcity of the buffalo, upon which they are at present entirely dependent. I took some trouble to enquire into this subject, and though I found the prevalent belief to be as I have stated, yet I was informed of several instances of cattle having been lost in the fall, and in every case they had not only survived but had been recovered in excellent condition in the following spring.

Such facts speak for themselves; but in any case the question is one of such immense importance to the country, that I may perhaps be permitted to suggest here as deserving the consideration of the Government whether it would not be advisable to devote a sum of money for the purpose of thoroughly and practically testing it, and at the same time endeavour to enlist the services of the Indians in the work.

The plain Indians.

To convert the plain Indians into tillers of the soil might never be accomplished, but to induce them to undertake pastoral pursuits would, I conceive, not be attended with similar difficulties. Already they rear and tend large herds of horses, and there seems no good reason why, when the necessity of supplying themselves with food has arisen, they should not be induced to rear cattle also. At any rate the experiment is worth a trial, and may, I think, be said to offer a fair probability of success if carried out with the requisite intelligence and energy.

Cultivation.

With the exception of the limited extent of land which is cultivated at the Hudson's Bay posts and at the various mission stations, no cultivation has yet been undertaken on either of the higher prairie levels. We saw abundant proof, however, at Edmonton, Victoria, Pitt, and Prince Albert of the fitness of the soil and climate for the growth of cereals and of all kinds of vegetables, which can be successfully grown elsewhere, even under more favourable conditions as regards elevation and latitude. It would be impossible in any part of the world to see finer barley, wheat, potatoes, turnips, carrots, onions, and cabbages than those we saw growing at Victoria, and at the St. Albert R. C. Mission Station, near Edmonton. Even at Rocky Mountain House, a hundred miles nearer the mountains and according to my observations 3,432 feet above the sea, barley, potatoes, turnips, and onions were being grown successfully, while on the farm of Mr. McKenzie, only 62 miles west of Fort Garry, the crops, which included wheat, barley, oats, rye, peas, beans (French and broad), potatoes, onions, carrots, swedes, turnips, mangolds, cabbages

and Timothy grass, would I believe compare favourably with the best crops of the same description grown in any part of Canada, or even in Britain.

The returns given me by Mr. McKenzie of the following crops were, per acre: Wheat, 30–40 bushels; oats, 50 bushels; barley, 35–40 bushels; potatoes, 300-400 bushels; turnips, 600–700 bushels, and peas, 20–25 bushels. Mr. McKenzie has 140 acres under cultivation, and no better or more practical illustration could be desired than is afforded by this farm, of what the soil of these magnificent prairie lands is capable of when cultivated with intelligence and enterprise. Crops.

Not many years ago the region we traversed was swarming with buffaloes; now, their skulls whitening on the plain, and the deep worn and grass-grown tracks which traverse the prairies in all directions, are the only evidence of their former existence. Not a single buffalo was seen during the journey, and very little large game of any kind, only a few antelopes or *cabri*, one moose and one red deer. Foxes, wolves, badgers, skunks, minks and beavers were seen or heard occasionally. Muskrats are very abundant in all the rivers and swamps, and swarm in the delta of the Saskatchewan. The officer in charge at Cumberland House informed me that he had last year collected and sent away 240,000 skins of these animals. On the prairies the little "gopher" or ground squirrel, (*Spermophilus Franklini*,) is almost equally abundant. It is about the same size or a little larger than the Canadian chip-munk, and its habits appear to be similar to those of the prairie-dog of the southern prairies. Like them they live in colonies underground on the open treeless prairies, and are generally seen sitting erect and motionless on their hind quarters either perched on the hillocks or in the grass near their burrows, into which they quickly disappear at the least alarm. Their skin is of no value, and, except foxes, they have few enemies to contend with in the "struggle for life." Moles, judging from the large earth-mounds thrown up by them over extensive areas, though we did not see any, must be almost as numerous as the "gophers." The moles seem invariably to select the tracts of deep rich black soil, and the marmots and badgers the intervening dry, sandy and gravelly ridges, so that between them the greater part of the surface is more or less burrowed, ridged and furrowed; and where this is the case the prairie, which would otherwise be as smooth and even as a lawn, becomes not only exceedingly rough and unpleasant to travel over on wheels, but also very dangerous to horsemen, and often fatal to the wooden cart-axles. Extinction of the buffalo. Quadrupeds.

Of feathered game we could always procure while on the plains as much as we required. From Red River to Rocky Mountain House prairie chicken (*Tetrao phasianellis*) abound; ducks of various kinds swarm upon nearly all the lakes and pools, and geese are frequently seen especially on the saline lakes. The geese are, however, not easily Birds.

approached, and without a good dog to bring them out of the water neither geese nor ducks when shot can be secured, except by wading through the broad belt of mud and high reeds by which nearly all the lakes are more or less encompassed. Cranes, bitterns, plovers, sand-pipers, snipe and other waders, as well as pigeons, black-birds, larks, and a number of other small birds, are plentiful on the prairies, or in the swamps, or along the river valleys, and crows and several kinds of hawks are very common. On our passage down the river in September and October large flocks of "wavys," grey, and black and white geese, and of the large blue cranes, were frequently seen flying southward, generally at a great height; a few wild swans and pelicans were also seen passing in the same direction. Between Fort Pitt and to near the elbow of the north branch a good many magpies were seen along the river, but none were observed elsewhere. I am told that these birds are very common on parts of the Qu'Appelle River and of the South Saskatchewan, but I believe they are not met with eastward of Red River. West of Cumberland, or Pine Island Lake, in the great delta of the Saskatchewan, numbers of large white owls were seen sitting perfectly motionless, perched either on boulders or snags, or on some of the many small patches of bare sand just appearing above the level of the surrounding waste of water and swamp which was here seen stretching on all sides as far as the eye could reach.

Magpies.

Fishes and their distribution.

There are very few fishes of any description in the Saskatchewan above its confluence with the South Branch; but from Fort à la Corne downwards to Lake Winnipeg, sturgeon, white-fish (*Coregonus albus*), and other excellent varieties are abundant. So far as I could ascertain there are no fishes at all in any of the numberless lakes and pools on the prairies between Red River and Carlton. West and north-west of Carlton and Edmonton, however, and in most of the lakes, many of them of large size, along the watershed between the Mackenzie and the Saskatchewan, white-fish are said to abound. Jack-fish Lake, described pages 33, 34, and Lake St. Anne, are two of these lakes in which they are annually caught in large numbers. Many of the lakes which we passed between Fort Ellice and Carlton, especially some of those in the Touchwood Hills, seem to be as well suited for fish as others do where they abound, and the cause of their partial and irregular distribution in the country is not very apparent, though perhaps a careful investigation of the character of the water in the different lakes would afford a satisfactory explanation of the circumstance.

ALFRED R. C. SELWYN.

Montreal, May, 1874.

APPENDIX.

MEMORANDUM ON WESTERN COALS, IRON-ORE, &c.,

BY

BERNARD J. HARRINGTON, Ph.D.,

CHEMIST AND MINERALOGIST TO THE SURVEY.

Six specimens of coal were examined with the following results: *

1. A bright black coal, breaking with angular fracture and giving a brick-red ash. Two proximate analyses by slow and fast coking gave—

	Slow coking.	Fast coking.
Water	7.82	7.82
Volatile combustible matter	31.35	38.00
Fixed carbon	54.97	42.25
Ash	5.86	5.93
	100.00	100.00

2. This specimen differed in appearance from all the others, having a somewhat greasy lustre, and breaking with a conchoidal fracture. It contained—

	Slow coking.	Fast coking.
Water	11.81	11.81
Volatile combustible matter	32.75	36.58
Fixed carbon	53.26	49.40
Ash	2.08	2.21
	100.00	100.00

(The powder was not at all fritted. Ash bright brick red.)

3. A dull black coal with marked planes of bedding and cleat, and containing much mineral charcoal. Two analyses gave—

	Slow coking.	Fast coking.
Water	10.90	10.90
Volatile combustible matter	28.69	36.22
Fixed carbon	54.96	47.84
Ash	5.45	5.04
	100.00	100.00

On exposure this coal cracks and falls to pieces. The powder was not fritted by either slow or fast coking. Ash brownish-grey.

4. Similar in appearance to No. 3 and containing—

	Slow coking.	Fast coking.
Water	12.93	12.93
Volatile combustible matter	26.80	34.12
Fixed carbon	52.28	44.95
Ash	7.99	8.00
	100.00	100.00

* See page 49.

By fast coking a few particles were slightly sintered together. Ash light grey.

5. A bright black coal, with irregular fracture, and showing thin veins of calcite, and occasionally also of pyrites. Probably from the same seam as No. 1, but containing more earthy matter. It contained—

	Slow coking.	Fast coking.
Water	7.50	7.50
Volatile combustible matter	31.46	37.06
Fixed carbon	51.19	45.48
Ash	9.85	9.06
	100.00	100.00

The powder was very slightly fritted by fast coking. Ash greyish-red.

6. Similar to No. 3. Analysis gave—

	Slow coking.	Fast coking.
Water	11.09	11.09
Volatile combustible matter	28.33	32 49
Fixed carbon	53.25	49.40
Ash	7.33	7.02
	100.00	100.00

As with No. 4, a few particles were slightly sintered together. Ash pale grey.

These coals may all be classed as brown coals, although in physical characters all but one (No. 2) resemble bituminous coals of the true Carboniferous. Numbers 1 and 5 come the nearest to bituminous coal, but still contain a considerable proportion of water, and communicate a deep brown color to a solution of caustic potash. Numbers 2, 3, 4, and 6 seem all to crack and fall to pieces on exposure, while numbers 1 and 5 are but little affected. For this reason the former are not well suited for distant transportation, and should be employed as soon as possible after mining. On the other hand, numbers 1 and 5 could be stored for any reasonable length of time, and are best suited for transportation.

Regarded as brown coals, they may all be considered the best of their kind.

Clay iron-ores. Three samples of the clay iron-ores from Edmonton were assayed by Mr. C. Hoffmann, and gave an average of 34.98 per cent. of metallic iron. They seem to be rich and valuable ores, and are all carbonates, with an external coating of hematite.

Soap clay. A sample of the soap clay from Edmonton (see section page 38) was analysed by Mr. Hoffmann, and gave—

Silica	36.48
Alumina	13.48
Protoxide of iron	1.80
Lime	2.03
Magnesia	0.66
Water, (loss by ignition)	44.32
	98.78

Alkalies were not determined though they probably make up the deficit. The material was not dried, but analysed in the moist condition in which it came from the bed. Its colour is pale greenish-grey; consistence that of soft dough; unctuous: when rubbed on the hand with a little water has a soapy feel, and possesses detergent properties; readily parts with its water, even at the ordinary temperature of the atmosphere. After drying at 100° C. may be reduced to an almost impalpable powder, which on being moistened with water, assumes all its original physical characters.

B. J. HARRINGTON,

Montreal, May, 1874.

REPORT

ON THE COUNTRY BETWEEN

RED RIVER AND THE SOUTH SASKATCHEWAN,

WITH NOTES ON THE GEOLOGY OF THE REGION BETWEEN

LAKE SUPERIOR AND RED RIVER

BY

MR. ROBERT BELL, C.E., F.G.S.

ADDRESSED TO

ALFRED R. C. SELWYN, ESQ., F.R.S., F.G.S.,

DIRECTOR OF THE GEOLOGICAL SURVEY.

General instructions.

SIR,—Having been entrusted by you, last winter, with the duty of working out the Geology of the coal-fields of the Saskatchewan Valley, I proceeded in the Spring by the Canadian route to Fort Garry, where I met you in July and received your instructions for the summer's operations.

Geology of Canadian route to Red River

The central portion of the Canadian route from Lake Superior to Red River had not previously been examined by any officer of the Survey. I therefore took care to ascertain as well as circumstances permitted the geology of this section, and the results of my observations will be found in this report.

Written instructions.

In addition to your general instructions to work out the Geology of the region westward from Red River as far as the 108th meridian, or a short distance beyond the elbow of the South Saskatchewan, on reaching Fort Ellice I received your detailed instructions in writing, as follows :

"FORT ELLICE, 6th August, 1873.

"SIR,—In carrying out the Geological Exploration which I have requested you to undertake this season, you will have the goodness to be guided by the following general instructions.

Limits of exploration.

1. You will not proceed westward of the 108th meridian, as shown on Palliser's map, a few miles west of the elbow of the South Saskatchewan River, nor to the south of the 50th parallel of latitude; and unless you should find it necessary to visit Fort Carlton, do not cross the South Saskatchewan.

2. The valley of Long, or Last Mountain Lake, should be examined and surveyed, and the nature of its connection with the South Saskatchewan Valley determined. The same would be desirable as regards the valley of the Qu'Appelle River by Sand Hill Lake. Last Mountain Lake.

3. It will also be desirable to examine and make such surveys as time and opportunity permit, and the character of the creeks themselves appear to warrant, of as many of the other tributary streams, and of the lakes both north and south of the Qu'Appelle River, as possible; selecting for the purpose those streams which run in the deepest cut channels, and in which rock exposures may therefore be expected to occur. In the event of there being no natural rock exposures, it may perhaps be practicable to ascertain the character of the strata where the sides of the valleys are steepest by a small amount of excavation, in which case it would be very desirable to do so. Qu'Appelle Valley.

4. The positions of all the principal lakes met with should be approximately determined, and the character of the water in all noted, also whether they have permanent outlets, or are exhausted only by soakage and evaporation. Samples of the salt or soil in the beds of the lakes should be collected, and a gallon or two of the water might be evaporated, and the residue preserved for examination. Lakes.

5. As regards the collection of other specimens and of facts bearing on the geological structure, physical features, climate, soil, timber, &c., of the region, your experience in making such observations renders it unnecessary to give you any special instructions, as you will of course attend to these matters as fully as the time and means at your command will permit. Specimens and notes.

6. Sites, the most suitable as regards water, timber, and position, should be selected and noted for future boring operations. Sites for boring.

7. You will be careful to procure an experienced Indian or half-breed guide either here or at Fort Qu'Appelle, sufficiently well acquainted with the Indians you are likely to meet with to be able to communicate with them, and to explain your object in visiting the country. You will of course be extremely careful to see that none of the members of your party do anything likely to offend or irritate the Indians, and, should any visit your camp, it would be advisable in all cases to conciliate them by some small present of provisions or such other stores as you can spare. To avoid all risk of collision do not allow the members of your party to visit their camps or to hold any unnecessary intercourse with them. Indian guide. Conduct towards Indians.

8. As bases of operation you will have the H. B. Co.'s posts at Fort Ellice, Qu'Appelle River and Touchwood Hills. Should you find that a canoe or boat would be useful, you could probably procure one at Qu'Appelle. Starting points.

9. In paying for wages, supplies, &c., you can give orders on Mr. Finances.

McMicken, Winnipeg, which I have arranged to be duly honored by the officers in charge of the H. B. Co.'s posts within the region you are about to explore.

Journal.

10. A regular itinerary and journal should be kept, shewing distance travelled, time on the road and in camp, &c., &c. Daily readings of the barometer and thermometer should be recorded at 9 a.m., 3 p.m. and 9 p.m., especially when on lakes or encamped for several days in the same place.

Barometer and thermometer.

Duration of exploration.

11. You will carry on the exploration within the limits indicated as late in the season as possible, allowing yourself sufficient time to return to Winnipeg before the close of navigation and travel via Lake Superior. Should I reach Winnipeg before you do, I shall wait your arrival. If you get in first, you will make the best arrangements you can for the disposal or safe custody, as the case may be, of your horses, carts and other equipment, with a view to further operations next season, probably in the vicinity of Edmonton. The members of your party proceeding to Canada, should return at once via the Dawson road if still open.

Disposal of outfit.

12. In conclusion, I would wish to remind you, inasmuch as the greater part of the region to which your operations will be confined has already been generally explored and reported on by Captain Palliser and by Mr H. Y. Hind, that detailed observations and surveys are now required, rather than a general and hasty examination of a large area, which would probably not enable you to give much information not already available in the published reports and maps of these able explorers.

Palliser's and Hind's explorations.

I have the honor to be,

Sir,

Your obedient servant,

ALFRED R. C. SELWYN.

ROBERT BELL, Esq., C.E. F.G.S.

Geological Survey of Canada.

I also received your supplementary instructions, dated 7th August, in which you direct us, in the event of our horses being stolen by Indians, not to attempt to fight the latter in order to recover them, but in preference, to offer a reward for their return; and also to keep watch at night, changing the guard every two or three hours.

Guarding horses.

We endeavoured to carry out all the foregoing instructions. In reference to the second head, however, on reaching Last Mountain Lake we found no appearance of rock *in situ*, and we were credibly informed by those intimately acquainted with the whole lake that none was to be seen

Last Mountain Lake.

upon its shores. Instead of curving north-westward or towards the South Saskatchewan, as represented upon the map referred to, it appears to curve north-eastward or away from it, and I could hear of no kind of connection between the lake and this river. The lake is about fifty miles in length. No boats or canoes were to be had in which to carry on a survey, and even had they been procurable, the whole of the remainder of the season available for work would have been consumed in making a survey of such magnititude. But had it been ever so desirable to make this survey an insuperable obstacle presented itself in the fact that no arrangement had been made by the government with the Indians to allow of surveys being prosecuted, and we found them very jealous of their right, and opposed to all kinds of surveys, and even explorations, especially when they had any thing to do with rocks or mines; "for," as they remarked to me, "if our lands are barren and we have nothing to fear from the encroachments of the farmers, we are afraid of the miners. White men come further for gold than for corn." They eventually compelled us to turn back and leave their country, which we did peaceably, as we were instructed on no account to come into collision with the natives.

Indians opposed to surveys.

As it happened, our time proved to have been well spent after leaving Last Mountain Lake, inasmuch as we discovered numerous workable seams of lignite and also the existence of deposits of clay iron-stone in localities far removed from any in which these minerals had been previously reported; and also gathered much useful geological and other information n referenc to the country lying between the Qu'Appelle and South Saskatchewan and the United States boundary line.

Discoveries of lignites and iron-stones.

FROM RED RIVER WESTWARD.

I arrived at Fort Garry on the 17th of July, and some days were consumed there in obtaining horses, carts and supplies. We left again for the west on the 25th of the same month, my party consisting of Messrs. Geo. F. Lount (who had assisted me during the two previous seasons), J. C. Young, Neil Campbell, John Allen, W. G. Armstrong and T. F. O'Brien.

Party.

In the arrangement of this report, I propose in the first place to give a brief sketch of the route followed, both in going and returning; then to describe, consecutively, what we saw in the districts examined, and in conclusion to give a *résumé* of the purely geological results of the expedition.

Arrangement of this Report.

As our object, in following out your instructions, was to reach the Valley of the "Qu'Appelle" or Calling River and South Saskatchewan, and the country lying to the southward, we pushed on as quickly as possible to Fort Ellice, following the trail north of the Assineboine by way of Prairie Portage and Pine Creek. A short distance west of Fort

Route followed

Fort Ellice.

Ellice, we descended to the bottom of the valley of the Calling River and followed it all the way to the Hudson's Bay Company's post at the Fishing or Qu'Appelle Lakes, in order to have an opportunity of seeing any rock exposures which might occur in the banks of the river itself or in the ravines intersecting them. From Fort Qu'Appelle, where we secured the services of Mr. Charles Pratt, a native missionary, as guide, we still followed the bottom of the valley, westward, except at a few places when it became impossible, as far as the outlet of Last Mountain Lake. Here we ascended to the prairie on the north side of the upward continuation of the Calling River, and which is known as the Big Arm River, and kept a nearly straight course to Sand Hill Lake, having in the interval touched the Little Arm River, which enters the west side of Last Mountain Lake. From Sand Hill Lake, we followed the valley of Big Arm River to the height of land, and thence down a small brook, which flows westward in a continuation of the valley of Big Arm River, to the elbow of the South Saskatchewan River. We next turned south-westward, intending to visit the Swift Current Creek, and if possible the Cypress Hills, for the purpose of examining the coal which, we were informed, occurs at these localities, but we had only proceeded forty-five miles, when we were met by large numbers of Indians who compelled us to turn back. We, therefore, proceeded with the examination of the remainder of the region assigned to us, lying to the south of the Calling River. Starting from a point on the south bank of the South Saskatchewan, our route was south-eastward past the northern extremity of the Old Wifes' Lakes and thence to the Dirt Hills. Here I left the party encamped and started on horseback with Mr. Pratt as guide, to make an examination of the Woody Mountains, which lie about sixty miles to the south-westward. On rejoining my party, we left the Dirt Hills, and reached the site of the old Qu'Appelle Trading post, from which, Mr. Lount and I proceeded to Fort Ellice, by way of the Little Touchwood Hills, while the rest of the party travelled by a direct route to the same point. From Fort Ellice, we returned to Fort Garry by a trail which keeps to the south of the Assineboine River, as far as "The Rapids," below the junction of the Rapid or "Little Saskatchewan" River, where it crosses the Assineboine and joins the northern trail two miles west of Pine River. We reached Fort Garry on the 15th of October, and returned home by one of the Red River steamers to Fargo, and thence by railway via St. Paul and Chicago.

Qu'Appelle Lakes.

Mr. Charles Pratt.

Fort Qu'Appelle to Elbow of South Saskatchewan.

Turn S. W.

Turned back by Indians.

Old Wife's Lakes, Dirt Hills.

Woody Mountains.

Fort Qu'Appelle

Little Touchwood Hills.

Fort Ellice to Fort Garry

Return home.

Some sections of the country which we examined had been visited by Dr. Hector, of Captain Palliser's expedition, and by Professor Hind, but the greater part of it was unexplored either geologically or topographically, and was a blank on the best maps of our north-west territories. While taking advantage of the labors of these gentlemen, we did not follow in

Unexplored region.

their footsteps, but confined ourselves to new ground. Being aware that Mr. George M. Dawson, naturalist to the International Boundary Commission, would probably examine the country through which the line passed as far as it might be run during the season, we avoided that section also, and had ample room for our labours elsewhere. **International boundary survey.**

The whole of the country which we explored is of a prairie character, with clumps of bushes and groves of trees in some parts. The greater part of it is hilly, and it is all so overspread with drift as to conceal the underlying rocks except at rare intervals. The exposures of the latter are mostly in the banks of rivers and ravines, and on the steep slopes of some of the higher hills, such as the Woody Mountains and Dirt Hills. A careful study of the drift itself is very important, both in reference to the distribution of the older rocks and the discovery of the useful minerals which they may contain. **General character of country.** **Drift.**

The valley of the Calling River is less than a mile in width and is very uniform. The name of the river is said to be derived from the fact that the width of the valley is just about as far as one person can be heard calling to another. In ascending the valley the first rock *in situ* under the drift which we noticed was on the southside at the junction of Scissors Creek, about thirty miles from Fort Ellice, and consists of a considerable thickness of drab-grey shale, weathering to a light colour, exposed towards the top of the bank on projecting points, from which the wind and rain have removed the surface covering. The debris from these bluffs contains many fragments of yellowish-drab clay-ironstone, weathering nearly black on the surface. They are derived from beds from two to three inches in thickness. The specimen which I brought from this locality is found to contain 23.72 per cent. of iron. At a point on the opposite side of the valley, about two miles north of the last, a section of about fifty feet of the same rock is exposed at the top of the bank. The dip is here southward at an angle of seven or eight degrees. Numerous fragments of ironstone, some of them six inches in diameter, similar to the last-mentioned, were observed in the material which had fallen from the cliff. There were also fragments of chert and of amber-coloured calc-spar. Similar shales and also drab-coloured marls continued to be exposed on the same side for a distance of two miles further. The dip continued to be southward, but the inclination had diminished to five or six degrees. Small exposures of similar shale were seen in a few places all the way to Round Lake, but in going west the dip appears to change from south to east. In this part of the valley, wherever the wind or rain has carried off the lighter materials, the surface is found to be thickly strewn with small pieces of the black-weathering ironstone. **Calling River.** **Rocks *in situ*.** **Ironstone.**

The Qu'Appelle or Fishing Lakes lie in a chain in the bottom of the valley, which, however, is not much wider where they occur than else- **The Fishing Lakes.**

where. The lowest or first lake is about nine miles long, the second, three, the third, six and the fourth, eight. They are separated from each other by strips of comparatively low land, which, in some parts, are thrown into terraces, showing higher levels of the lakes in former years. Fort Qu'Appelle, the Hudson Bay Company's post, stands between the second and third lakes, and is 140.28 miles from Fort Ellice by the course we followed. I should here mention that we ascertained our distances by means of an odometer attached to an iron-bound wagon-wheel. We also noted the direction of each course which we followed. Round Lake and Crooked Lake, which occur on the course of the Calling River about midway between Fort Ellice and the Qu'Appelle Lakes, are similar to the latter, and measure about six and eight miles in length, respectively. The banks of the river all the way from its junction with the Assinneboine to "the Forks," or junction of the outlet of Last Mountain Lake, are pretty uniform in their height, which averages about 200 feet; but the land often rises 100 feet higher a short distance back from the valley. The river is only from half a chain to a chain in width, and sweeps from side to side of the valley. Each principal curve comprises a great number of subordinate ones, closely crowded together, rendering the navigation extremely tedious. The current is swift, but there is no obstruction to the descent of small boats from the Qu'Appelle Lakes to the Assinneboine. The north bank and the bottom of the valley on the north side of the river are almost destitute of timber, while the south bank, with northern exposure, is generally well wooded. The banks are broken down into a multitude of peaked or more or less conical hills of all sizes, which are usually thickly strewn with boulders. The latter consist of gneiss, light-grey limestone, micaceous, dioritic and other schists, like those of the Huronian formation. Pebbles and small boulders of white quartz, apparently derived from veins, are also of frequent occurrence.

Odometer measurements.

Character of Calling River and its banks.

Boulders.

From the Qu'Appelle Lakes westward to the Forks, the valley of the Calling River maintains the same character which it has below the lakes. The banks, especially in exposed situations, are strewn with boulders of the same kinds of rocks, and in addition to them, I frequently noticed small ones of compact pinkish-grey sandstone, usually well rounded. The bottom of the valley in this section was almost everywhere covered with a luxuriant crop of tall grass which was said to make excellent hay. North of the valley the prairie is of a rolling character and is interspersed with clumps of bushes. The soil is a drab-coloured gravelly loam with a black layer on the surface in the low lands. Boulders are abundant in some parts, while in others the surface is tolerably free from them.

Luxuriant grass.

Soil.

The outlet of Last Mountain Lake is about four miles from the Forks, or junction of the valley of the Big Arm River. The valley between these two points is from one half to three quarters of a mile in width, and

is 300 feet, by barometric measurement, below the general level of the surrounding country. At the time we crossed it, (20th August), it was quite dry and flat, there being no channel by which the water of the lake might flow to the Forks, but it may overflow the whole breadth of the valley early in the spring. At the foot of the bank on the east side a low ridge of bare worn gravel shews a former higher level of the water.

In going from the foot of Last Mountain Lake to Sand Hill Lake we passed over an open rolling prairie with ponds of fresh and of brackish water. The soil is a gravelly drab-coloured loam of poor quality, usually thickly strewn with boulders, which are particularly abundant in the valleys, or low grounds between the hills, and around the dry beds of ponds. Sometimes also on the higher grounds the boulders are formed into low ridges with scarcely any admixture of soil. The valley of Little Arm River is between 200 and 300 feet deep, and along the bottom of it a strip of bright green wood, is sometimes seen, forming a pleasing contrast to the monotonous grey of the prairies above. This valley runs parallel to that of Big Arm River, and terminates on the west side of Last Mountain Lake. Both valleys form an elbow to the south, opposite to each other, and it is from this circumstance that they have been called the Big and the Little Arm River respectively. Sand Hill Lake region. Little Arm River.

We had been informed that fossil bones and traces of lignite had been found at Sand Hill Lake, but on searching we could find neither. The clay at the bottom of the banks of the lake bore some resemblance to that just below the drift at the Elbow of the South Saskatchewan, and which appears to be of Tertiary age. Fossil bones.

As already mentioned, the valley of Big Arm River is continuous with that of a small brook which runs westward into the South Saskatchewan at the Elbow. In approaching the height of land between them, the valley becomes wider, and the banks are much less abrupt, the plain sloping gently down from either side. The dividing point of the waters is marked by a low swelling across the bottom of the valley. About two miles and a half east of the height of land a low ledge of sandstone is exposed below the bank on the north side of the valley. The rock is of a greenish-grey colour, weathering brown, and holds abundance of *Avicula linguæformis*, but no other fossils were observed. It would therefore appear to belong to the Cretaceous period. The ledge is only about four feet high, but it is exposed for a distance of about fifty feet. The dip is due west at an angle of five or six degrees. Valley of Big Arm River. Height of Land. Sandstone.

The Sand Hills begin on the north side of the valley about two miles west of Sand Hill Lake and continue for several miles. The exceptional abundance of sand at this locality is probably owing to the existence of beds of sandstone in the neighbourhood, since we observed that in these prairies, as everywhere else in Canada, the materials of the drift The Sand Hills.

are largely made up of the debris of the solid rocks immediately beneath or a short distance off in the direction from which the disintegrating force moved.

Distances. The distance from Fort Qu'Appelle to the Elbow of the South Saskatchewan by the above route was found by the odometer to be 146 miles, or from Fort Garry by our course about 506 miles. Professor Hind gives the distance as 548·41 miles from Fort Garry. Coal. Coal was reported to have been discovered at the Elbow, but after a careful search along the east side of the river from a point two or three miles below the Elbow to one about ten miles above it, we failed to discover anything but loose pieces of lignite similar to that hereafter to be described as occurring at Dirt Hills, Woody Mountains and on the Souris River. The south-east side of the section of the river lying between twenty and forty miles above the Elbow was also examined, as well as the north-west bank at about thirty-five miles, without detecting any trace of coal or lignite, so that it is probable that the beds from which the fragments above alluded to are derived, exist somewhere within the first twenty miles above the Elbow. Probable position of lignite beds. In this part of our journey we met with an intelligent Indian, who had acted as school master at the Mission at Touchwood Hills. He informed us that he had seen lignite, like the specimens which we shewed him, in the north bank of the South Saskatchewan, a short distance below the junction of the Red Deer River and also a short distance above that stream. Lignite near Red Deer River. A tributary of the South Saskatchewan, called the Swift Current Creek, which is well known in this part of the country, bnt which is not marked on the maps, flows from the Cypress Hills and joins the river about half way from the mouth of the Red Deer River to the Elbow. Swift Current Creek. Lignite. Lignite is reported to occur in large quantities in the banks of this stream, and I was presented with a specinen, of a good quality, said to have been taken from a bed *in situ*. Mr. Isaac Cowie of the Hudson's Bay Company, who had spent the winter before last among the Cypress Hills, informed me that he had seen much lignite on a hill about a mile and a half from the site of the Company's houses, which have since been burnt. Lignite at Cypress Hills. Fossil bones. Large bones like those of the mammoth are said to be found on the surface at the White Mud River, a small tributary of the Missouri on the west side of the Cypress Hills.

The distance from the Elbow of the South Saskatchewan to the foot of the Red Ochre Hills was found to be thirty-two miles. In this interval the banks were found by the aneroid barometer to average a little over 200 feet, while the tops of the Red Ochre Hills varied from 500 to 550 feet above the river. Red Ocher Hills. This elevated ground stretches for a considerable distance to the south and south-east, and presents an extremely hilly appearance. Composition of the hills. The hills as far as can be judged from their outside appearances, and the materials thrown out of the badger holes, are composed of

very gravelly earth, in which smooth pebbles of finely granular quartz predominate. These are mostly white, but some are grey, brown, pink and red, the latter often passing into banded compact sandstone. There are also pebbles of dark fine-grained diorite, light coloured limestone and some of dark fine-grained mica schist and of white translucent quartz, the last mentioned being often rough-surfaced.

In this region, there are numerous ponds and small lakes in the hollows among the hills, most of them being more or less brackish or nauseous to the taste from the presence of the sulphates of magnesia and soda and other salts. During the dry season of autumn, the water evaporates completely from many of these ponds leaving their beds covered by the dry white salts, which look like snow and are blown about in the wind. Around all the ponds, except those which become completely dry, there is a rank growth of reeds, sedges and grasses, the deep green colour of which forms a strong contrast to the dull grey appearance of the stunted and scanty grass of the hills, which indeed, in many places, are almost bare. Brackish ponds.

On the west side of the Red Ochre Hills, land slides in the bank of the South Saskatchewan expose sections in the lower part of the slope, of at least 300 feet of grey and drab marly clays with rarely a bed of soft sandstones two or three feet thick. The upper part of the bank consists of bouldery clay, sand and gravel belonging to the drift period. Some bands of the underlying marly clays are of a dark colour, owing probably to the presence of carbonaceous matter. On exposure to the dry air these clays become " heaved," much in the same manner as black loam when exposed to frost. In walking over a surface thus loosened one sinks to the ankles. This heaving action of the clay appears to be due to the efflorescence of the salts with which it is impregnated. It also contains numerous elongated crystals of selenite of the average size of one's finger, which lie thickly scattered on the surface and glitter in the sun like broken glass. Along the edge of the river, below these high clay banks, there is exposed a coarse crumbling arenaceous rusty greenish-grey shale with irregular thin bands, and also patches, two or three feet thick and several yards wide, of greenish-grey sandstone full of *Avicula linguæformis*, the same fossil which is so abundant in the sandstone near the height of land at the head of Big Arm River. The shells are well preserved, and retain their white pearly character. A single specimen of *Baculites* was also found, containing within it several shells of the above mentioned *Avicula*. A specimen of clay-ironstone, apparently derived from the shale contains a single valve of *Inoceramus*. On the face of one of the clay banks at this locality an angular piece of silicified wood, a foot long, was found. From microscopic examination, Dr. Dawson thinks it belongs to a spieces of pine, but the

Section of marly clay.

Crystals of Selenite.

Sandstone with *Avicula*.

minute structure was found to be less perfectly preserved than the outward appearance of the specimen indicated.

From a point on the south-east bank of the South Saskatchewan, about forty miles above the Elbow, we followed a south-easterly course to the northern extremity of the most northern of the Old Wife's Lakes, which we reached at twenty-four and a-half miles from the river bank, according to our odometer measurement. These lakes are three in number, and appear to lie in a chain running about N.N.W. and S.S.E. They are said to be connected with each other by narrow straits, and to have a total length of thirty or forty miles. The middle lake receives a stream called the Old Wife's Creek, which flows from the direction of the Cypress Hills, but none of the lakes have any outlet. The water is very clear and extremely nauseous to the taste. There is a considerable quantity of white salt around the shores in the dry season, a specimen of which is found to consist of

Old Wife's Lakes.

The country around the northern extremity of the Old Wife's Lakes is not so hilly as that between this point and the Saskatchewan.

Leaving the north end of the Old Wife's Lakes, we kept as nearly straight a course as possible to the north-eastern point of the Dirt Hills, which we found by the odometer to be eighty-six miles distant. In this interval the surface is generally of a rolling character, and the soil in the valleys and more level parts appears to be derived directly from clays like those exposed in the high banks of the Saskatchewan at the point where we left it. However, pieces of clay-ironstone were found upon the surface of these clays. The higher grounds are occupied by gravelly earth with boulders. The clayey ground in this part of the country is rendered " hummocky " and difficult to travel over by carts, owing to the fissures produced by drying in former years. These fissures divide the ground into spaces, usually five-sided, from one to two yards in width. The edges of the fissures, by falling in, have gradually converted the intervening spaces into dome-shaped mounds which are hard and unyielding. These principal hummocks are again divided by minor fissures of more recent date. This kind of surface extends alike over the flat bottomed hollows and low swelling hills. In the country inhabited by the buffalo, the surface is roughened in another way; namely, by the tramping of the animals when crowding round the shallow ponds to drink. When the ponds have completely dried up and the ground has become hard, these places are so rough that they require to be carefully avoided when travelling with carts.

Dirt Hills.

Clays with ironstone.

Sun cracks.

Dirt Hills.

The Dirt Hills are a conspicuous north-eastward projection of a range of hills running from the Old Wife's Lakes south-eastward to the Long River (a branch of the Souris) and forming a sudden rise from the prairie lying towards the Assinneboine River. In going from the northern

extremity of the above lakes to the Dirt Hills, we touched upon another northward projection of the same rise at exactly half the distance between these localities. This rise or " coteau " consists in reality of the ruins of an escarpment, and its broken and irregular character is due to the softness of the rocks of which it is composed. Above or to the south of this rise, the country is extremely hilly, interspersed with ponds and small lakes of fresh and bitter water, and destitute of wood. The hills appear to be composed of gravelly earth with boulders resting upon clays similar to those last described. The grass is short and sparse, and occasionally, for miles, the surface consists of almost bare gravel and boulders, the latter

Projection of the Coteau.

Hilly country.

After consist of, on line 15, page 76, *read*, sulphates of lime and magnesia with smaller quantities of carbonates of lime and magnesia and soluble chlorides.

tance into the plain. The strata in this locality appear to be about horizontal, but in the great masses detached by the land-slides they are tilted up to various angles as high as 45°, the slope being to the south-westward; while the undermining force has evidently acted from the north-eastward. The large surfaces of bare and often muddy clay which are here exposed, contrasting with the grassy or gravelly prairies, have probably given rise to the name which these hills bear. Three of the bluffs formed by the land-sides are conspicuous at the north-eastern extremity of the Dirt Hills. They all contain beds of lignite, but their out-crops are almost concealed from view by the sandy clay which has been washed from above, and the whole of the face of a bluff in dry weather has a whitish appearance. Four seams crop out in the lower half of the middle bluff, which were found to measure, counting from the bottom, six, four, three and five feet respectively. In a smaller hill close by, there is a band of intermixed lignite and clay, seven feet in thicknesss. In some parts it is nearly pure lignite and in others largely made up of clay, shewing its qualities to be very local. The more solid parts of the lignite in most of the beds consist of dark brown half-carbonized wood which appears to be mostly of coniferous species. When newly dug, the splinters of this fossil wood retain a slight degree of elasticity, but on long exposure to the air, expecially in presence of water,

False dip.

Thickness of lignite beds.

Quality of lignite.

Character changed by exposure.

it becomes jet black, brittle and glossy like bituminous coal. While this change is taking place the bulk appears to diminish, the surface becomes divided by reticulating cracks and assumes a warty appearance. All the beds contain specks and small rounded lumps of brittle yellowish resin, or amber, and crystals of selenite were also sometimes found in them. Some of the more impure beds were full of flattened stems of plants from a few lines to upwards of six inches in breadth. These sometimes shewed branches on both sides and when moist were quite elastic, but the structure of their tissues is so far obliterated as to render it difficult to be distinguished by the microscope. From an examination of several specimens, however, Dr. Dawson believes them to be all stems and roots of coniferous trees.

Resin and selenite in lignite.

Plants remains.

Around the base of this part of the Dirt Hills much of the ground is quite bare, and resembles a surface which has been washed by the hydraulic process for gold. In these places it is strewn with nodules of sandstone and clay ironstone, washed out of the clays, and boulders of gneiss. The sandstone nodules are generally from the size of a man's head to three or four feet in diameter. They are sometimes nearly perfect spheres, but more frequently they are considerably flattened. They shew lines of stratification, along which they may generally be split without much difficulty. The ironstone nodules vary from the size of filberts up to a diameter of three feet. They have usually a drab colour on fresh fracture and a dark reddish brown surface, which is often reticulated by small ridges. Some of the thinner pieces of the ore are perforated by very small cylindrical holes surrounded by oxidised walls. A sample of the ore broken from one of the larger nodules gives per cent. of iron, so that these nodules constitute a rich and easily reduced ore. A large quantity of it might be gathered from the bare surfaces about the slopes and bases of the hills, without the necessity of mining or washing.

Ironstone.

Sandstone concretions.

Character and quantity of iron ore.

The results of the analyses of some of the lignite from this locality are given in the Appendix. Some of them appear to be of a sufficiently good quality to be fit for fuel. Owing to the action of the weather, some of the beds at their out-crops crumble to powder, but at a depth from the surface the lignite would probably be found to hold together sufficiently to form pieces suitable for fuel. In its natural bed it is completely soaked with water, and, indeed, owing to its being more open and porous than the clayey strata in which it occurs, springs were sometimes found issuing from the out-crops of the beds.

Quality of lignite.

As already stated, while I left my party encamped at the Dirt Hills I made an excursion on horseback to the Woody Mountains. This mode of travelling was considered advisable for the sake of expedition and to avoid being plundered by hostile Indians who were reported to be then in that neighbourhood.

Woody Mountains.

The Woody Mountains consist of a rather bold north-facing escarpment of arenaceous marly clays and soft sandstones with beds of lignite, cut by deep ravines, which almost isolate some portions from the main body. The north-eastern extremity of the Woody Mountains lies about S.S.W. from the point of the Dirt Hills above described and at a distance of about fifty-five miles from it. This would be some distance north of the International Boundary, although there is an impression among the Half-breed traders that these hills are situated very near that line. From its north-eastern extremity the broken escarpment was observed to trend off to the south and south-east till it had no doubt reached beyond the United States border; while to the west it is said to extend in about the same latitude for nearly a hundred miles. The approach to the north-eastern extremity of the mountain is cut off by a narrow saline lake which runs south-eastward for several miles between steep banks of massive grey sandy clay. Another saline lake lying at the base of the escarpment, and whose bed was covered with white salts at the time of my visit (7th Sept.), begins at ten or eleven miles from the above point. Continuing about due west, at the distance of about eighteen miles from the extremity of the north-facing escarpment, we entered an east and west gap or ravine in the mountains, with a small brook of good water running eastward in the bottom of it. We continued through the valley to a point between twenty-five and thirty miles from the commencement of the southern escarpment. In going from the Dirt Hills to the north-eastern extremity of the Woody Mountains we found the whole country extremely rough. In the first eight or nine miles the hills are particularly steep, and have numerous ponds of fresh water scattered among them. At this distance we passed over a general descent to a strip of country on a somewhat lower level, but also very hilly, having a chain of dry salt lakes running for many miles in a south-westerly direction. Only two regular valleys were crossed before reaching the long narrow lake at the base of the Woody Mountains, the first at about thirty and the second at about forty miles from the Dirt Hills. These both descended to the westward, and their sides are of a more clayey character than the hills.

Appearance.
Rocks.
Position.
Extent.
Saline lakes.
Gap in mountains.
Character of country between Dirt Hills and Woody Mountains.
Chain of salt lakes.
Two valleys.

The escarpments on either side of the east and west ravine, above referred to, are about 200 feet high. The bulk of the strata consists of light grey arenaceous marl passing into very soft fine-grained sandstone, with some coarser and harder beds of a red, and others of a greenish-grey colour. The dip is southward at the rate of about 100 feet in the mile. The strata are well exposed in several bluffs on the south side of the entrance to the above ravine. All these bluffs shew beds of lignite although they are almost completely hidden by the marl which has run down over their out-crops and turned nearly white in drying. In one of the bluffs which was more carefully examined than any of the others, eight, appar-

Character of the strata.
Lignite.

Eight seams. ently distinct, beds of lignite were discovered. They are separated from each other by an almost equal thickness of the marly strata. Of the two central seams, as nearly as could be judged by their out-crops, the upper is eight and the lower five feet thick. The others are all thinner. The uppermost three appear to be from one to three feet thick, and those below from two to four feet. The lignite of all the beds appears to be of good quality, and constituted like that of the Dirt Hills seams, already described. Besides nodules of clay iron-stone, a bed of this mineral eight or nine inches thick was observed near the bottom of the bluff, and a thinner one about half way up. Four, at least, of the lignite beds, or others replacing them, were traced by many exposures along the southern escarpment for a distance of about five miles from the above locality. In some places in this interval, some of the arenaceous beds in weathering away, leave large concretions, resembling in form curling stones and tortoise shells. Some of the concretions have a second riding on top of them. About these bluffs some large pieces of spongey clinker were noticed, which have probably been formed by the heat produced by the burning of some of the lignite beds in past years.

Thickness of lignites.

Quality.

Iron-stone.

Westward continuation of lignite seams.

Sandstone concretions

Clinker.

Plant remains. The plants forming the lignite beds appear to be of the same kinds as those of the Dirt Hills seams. A fragment of fossil wood from a ferruginous layer in the bluff above described has the tissues replaced by oxide of iron and tolerably well preserved. From a microscopic examination Dr. Dawson regards it as a species of cedar. Several partially silicified angular fragments of fossil wood were found on the newly exposed slopes of the bluffs, and appeared to be derived from these beds. They appear to be of different species of exogenous wood, one of which resembles the cotton wood, *Populus monifera*. A few small shells in a soft crumbling condition were found in two or three places in the marly beds, and others very poorly preserved in a thin bed of ironstone. In attempting to carry back some specimens of the former on horseback, they were unfortunately reduced to powder, although carefully packed and protected as well as possible from injury. One of them was a species of *Paludina*.

Shells.

Lignite in northern bluff. In the most conspicuous bluff on the north side of the part of the above ravine which we traversed, two beds of lignite were found towards the top or nearly 200 feet above the bottom of the valley. A bed of rather coarse grey sandstone seven or eight feet thick caps this bluff.

Sandstone.

From Dirt Hills to Qu'Appelle. From the base of the north-eastern extremity of the Dirt Hills to Fort Qu'Appelle the distance was ascertained to be about ninety-six miles in a north-easterly course. The first forty miles were over a swelling clayey prairie with the rough fissured hummocky surface already described, with only one strip of wood, which occurs along a stream called the Tattooed-tent Creek. Throughout the remainder of the distance the country is hilly with groves of poplar trees and clumps of willow bushes, and the soil has

changed from brownish and drab clay, to gravel, with black loam on the surface in the valleys and around the dry ponds. A light grey limestone enters largely into the composition of the gravel, the rest being made up of fragments of shale, gneiss, quartzite and crystalline schists. The country, for the last ten or twelve miles before coming to the valley of the Calling River, has become much more level, and the gravel is largely mixed with drab coloured clayey loam, and has a good surface-coating of black mould. The prairie is here between 250 and 300 feet above the bottom of the valley.

"Tattooed Tent" Creek.

The Tattoed-tent Creek is so called from "The Tattoed Tents"—two conical hills about forty feet in height, rising from its bed at the point at which we crossed it, about ten miles north-east of the Dirt Hills. These cones consist of nearly horizontal clayey strata similar to that of the Dirt Hills, and have a fanciful resemblance to some of the tattoed skin tents of the Indians. Much rock is exposed in the neighbourhood of "The Tattoed Tents," consisting of sandstones and the clayey strata just referred to. Although the latter bear a strong resemblance to the beds in the Dirt Hills, no lignite was found associated with them. The whole section at this locality amounts to between 100 and 150 feet. The dip is N. 60° E. at an angle of rather less than two, or about one in thirty. The strata consist mostly of the caking dark grey and drab clays and the light, fine, clayey sands already described, overlaid at the top by twenty or thirty feet of soft grey sandstone, which weathers to a reddish-brown colour. Some of the sandstone beds break into good rectangular blocks for building. The sandstones cap the irregular escarpments which occur on the east side of the creek. Their projecting points and detached outlines are covered with blocks of sandstone, causing them to resemble old ruined buildings. Among the lower soft strata in the banks of the creek is an arenaceous bed near the bottom of the section, filled with great concretions of sandstone some of them measuring seven feet in their horizontal diameter. Some of them show diagonal stratification, and they all appear to be the result of a partial concretion of the thicker portions of an irregular bed of sandstone interstratifying the clay. Smaller arenaceous concretions were found in some of the beds higher up. Nodules of clay iron-stone were strewn about in abundance on the denuded surfaces at this locality.

Rock exposures.

No lignite.

Character of strata.

Large sandstone concretions.

Ironstone.

From Fort Qu'Appelle to Touchwood Hills.

From the brink of the bank on the north side of the valley at Fort Qu'Appelle, the surface is very uneven all the way to to the Mission at Little Touchwood Hills, which we found by the odometer to be forty-eight miles from Qu'Appelle, and the direction about due north. Although all the streams in this section of the country flow south-westward, the general trend of the minor hills and valleys seemed to be nearly at right angles to this course. The surface soil in the above distance consists almost

everywhere of a rich black loam with a gravelly clay subsoil. Clumps and groves of trees and bushes are scattered everywhere, and in approaching the Little Touchwood Hills numerous small lakes of fresh water were seen. A clayey soil prevails on the Little Touchwood Hills, which are covered by a growth of poplar woods, the trees in some parts being large and valuable for building. The main road between Forts Ellice and Carlton lies at a distance of about twelve miles north-eastward from the above Mission. The track leading to it lies mostly through the woods, and passes several small lakes.

Little Touchwood Hills.

From Touchwood Hills to Fort Ellice.

The distance to Fort Ellice by the main road from the point at which we struck it, is 159 miles by our odometer measurement. The country in this interval is of an undulating prairie character, with numerous groves of poplar, except for a space of about twenty miles, which occurs nearly midway. Small lakes, which are nearly all of tolerably good water, are most numerous towards The Touchwood Hills, and disappear entirely in the second half of the journey. At about fifteen miles before coming to Fort Ellice, we entered upon a sandy plain which supports only a growth of the dwarf variety of the red cedar. The same character of country extends an equal distance west of Fort Ellice on the south side of the Assinneboine River.

Sandy plain.

Southern trail, Fort Ellice to Fort Garry.

Following the Southern Trail from Fort Ellice toward Fort Garry we crossed to the north side of the Assinneboine River at "The Rapids," which we found by the odometer to be about 102 miles from Fort Ellice, and joined the Northern Trail about two miles west of Pine Creek. The distance between the above forts by this route is about 235 miles, or fifteen more than by keeping the Northern Trail the whole way. Where the trail crosses one of the southern tributaries of the Assinneboine about twenty-five miles from Fort Ellice, a section of between twenty and thirty feet of horizontal beds of greenish-drab shale is exposed in the banks. A few fragments of clay iron-stone are mixed with the broken shale forming the talus.

Drab shale.

Character of prairie south of Assinneboine River.

In the country which we traversed to the south of the Assinneboine River the prairie is of a rolling character. The soil is mostly sandy and gravelly with a thin layer of black loam on the surface; but there are some belts of sand hills interspersed with scrubby oaks, and some tracts where the surface is much encumbered with boulders. Wood and surface-water were scarce throughout the greater part of this district.

General Description of the Geology of the Region examined.

Silurian limestones of Red River.

The valley of the Red River from Fort Garry to Lake Winnipeg appears to be underlaid by buff or cream-coloured magnesian limestone belonging to the Lower Silurian series. The age assigned to these rocks is based chiefly upon the evidence of a comparatively small number of

species of fossils which have been collected in the bed of the river at the Lower or Stone Fort. This rock has been used for building at St. Boniface and in Fort Garry. A similar rock occurs in the Stoney Mountain, an isolated hill, fourteen miles north of Fort Garry, which, according to Professor Hind, presents a cliff on the west side sixty feet in height. The lower part of the banks of the Assnineboine at Silver Heights, five miles west of Fort Garry, are composed of drift, made up almost entirely of the débris of the same kind of rock, and, judging from the angular character of the limestone fragments, as well as their abundance, the rock *in situ* must lie only a small depth beneath. Stone Fort. Stoney Mountain. Silver Heights.

The next higher rocks in the geological scale known to occur in this region are the compact limestones holding Devonian fossils, described by Professor Hind as occurring on various points and islands in Lakes Manitoba and Winnipegosis. Devonian rocks.

In the high grounds lying to the west of these lakes, known as the Pas, Porcupine, Duck and Riding Mountains, the only rocks discovered of which we have any definite account consist of one exposure of shale found by Professor Hind on the north-east side of the Riding Mountains, in which he detected traces of Cretaceous fossils. I have, however, been informed by surveyors who have been engaged during the last year or two in subdividing the lands in the Riding Mountains, that shale is found in the banks of ravines in many places in that region. Cretaceous shales are also mentioned by Professor Hind as occurring in one place in the banks of the Rapid River. He also noticed shales and sandstones of the same age in the banks of the Assinneboine, between the Rapid River and the Souris, (which joins it about twenty miles further down) and traced them for many miles up the latter stream towards the United States boundary. In the banks of the Souris the shales and sandstones were found to hold *Inoceramus* and other Cretaceous fossils. Professor Hind thinks there is but little chance of finding Carboniferous rocks in this region between the Devonian and the Cretaceous. This opinion he based on the fact that he could find no boulders, derived from Carboniferous rocks, in the drift, and also that in one place the Devonian rocks approach within ten miles of the Cretaceous, while the strata are nearly horizontal and leave but little stratagraphical space in which Carboniferous beds might be inserted. Riding Mountains, &c. Cretaceous age. Rapid River. Assinneboine River. Souris River. *Inoceramus.* Little chance of Carboniferous rocks.

It has been already mentioned that we found greenish-drab coloured shales with clay iron stone where the southern trail crosses a brook about twenty-five miles south-east of Fort Ellice, and Professor Hind found similar shales with Cretaceous fossils on the Assinneboine River at "The Two Creeks," about the same distance below Fort Ellice. The occurrence of these shales in the banks of the Calling River at several places between Forts Ellice and Qu'Appelle has been already described. Drab shale. "Two Creeks." Calling River.

Boundary between Cretaceous and Tertiary.

It will be very difficult to lay down the precise position of the geographical boundary between the Cretaceous strata and the Tertiary rocks with which the lignites above described are associated. This arises from the horizontal attitude and the prevailing soft character of both series, precluding the frequent natural exposure of the rocks, from and the great depth of the drift, which is almost everywhere spread over the country. The difficulty is still further increased by the fact that geologists have not agreed as to what strata in this region of North America shall be considered as of Cretaceous age and what Tertiary, the distinction being founded on the evidence of the fossil plants and animals which they contain. If for local convenience, we adopt a partially lithological classification, we might consider, as Tertiary, all the strata above the *Inoceramus* shales and sandstones of the Souris, the shales of the Calling River and the *Avicula* bearing sandstones of the neighbourhood of the Elbow of the South Saskatchewan. The strata of the "Coteau," extending from the South Saskatchewan at the Red Ochre Hills (thirty-two miles above the Elbow) to the Dirt Hills and thence south-eastward to the United States boundary would therefore be Tertiary, together with the clayey strata extending to a distance of thirty or forty miles to the northward of the foot of this Coteau. The line representing the geographical division between the two formations would therefore appear to enter British territory in the neighbourhood of the Roche Percé, where Dr. Hector found Tertiary strata with lignite, and to run thence west-north-westward to the Elbow of the South Saskatchewan, passing about forty miles north of the Dirt Hills. From the evidence afforded by the Woody Mountains and the Swift Current Creek, the whole area between this line and the United States boundary would appear to be occupied by the lignite-bearing Tertiary strata. Crossing the South Saskatchewan at the Red Ochre Hills, the Coteau runs northward, and, according to Dr. Hector, reaches the North Branch at the Eagle Hills. Judging from the descriptions of this geologist and from what I have been told by miners, Hudson's Bay Company's officers and Indians, the greater part of the area between the two branches of the Saskatchewan would appear to be occupied by these lignite-bearing strata.

Provisional distinction.

Course of geological line.

Roche Percé.

Coteau from Red Ochre Hills to North Saskatchewan.

Relations of sections to each other.

The 300 (or more) feet of apparently non-fossiliferous clays and marls observed at the Red Ochre Hills rest directly upon the beds holding *Avicula linguæformis* and other Cretaceous fossils. As already stated, these clays and marls appear to correspond with those at the "Tattooed Tents." The sandstone at the top of the section at the latter place is probably a continuation of the band at the base of the Dirt Hills. There would thus appear to be upwards of 300 feet of clayey strata, without observed lignite, below the horizon of this sandstone band, and about 600 feet of similar strata with lignite above it. The lignite beds appear to be

distributed through about 200 feet of strata in the Woody Mountains and through an equal, or greater, thickness exposed in the land-slides at the Dirt Hills. I may mention, however, that close to the summit of one of the highest points of the latter, the prairie squirrels brought up powdered lignite from several of their holes on the same level, shewing the probable existence of a horizontal bed of it at this high level. Position of lignites.

The beds which I have described as lignite are made up of the carbonized trunks and branches of trees (mostly of Coniferous species) and comminuted plant remains, without any visible admixture of other matter, such as sand or clay. There are, however, other beds in which these substances are largely mixed with the vegetable matter, and in these the forms of the plants are more distinctly recognizable. Dr. Dawson makes the following remarks in reference to some specimens from one of these beds at the Dirt Hills which were submitted to him: "The material has the aspect of a compressed mass of roots, branches and other vegetable fragments, with a little mineral charcoal and occasional small pieces of yellow resin. The branches and roots are flattened and in the state of lignite or jet, and are matted together and mixed with vegetable débris as if accumulated in a wet swamp or in a pond surrounded with forest. The mineral charcoal when prepared with nitric acid shews the structure of coniferous wood of the same type already recognized in so many lignites from this region, or resembling that of *Cypress*, *Sequoia* and *Thuja*. The most interesting specimens observed are a few flattened cones which, though not very well preserved, can be recognized as resembling those of the genus *Sequoia* and very near to those of the widely distributed *S. Langsdorfii* (Heer.) Taken in connection with the wood in this collection and in those of Mr. Selwyn and Mr. G. M. Dawson, and with the leafy branches in the collection of the latter, these remains shew that in the period of the Lignite Tertiaries, the plains east of the Rocky Mountains must have borne dense forests of coniferous trees, some of them of types now found on the west coast and indicating a more humid and equable climate than that which exists at present." Composition of lignites. Dr. Dawson's remarks. Cones. Condition of country in Tertiary period.

DRIFT.

It will be observed by the foregoing portion of this report that all the rocks which came under our observation were of a soft character. Their surface was therefore ploughed and broken up during the drift period in such a manner as to render its line of contact with the deposits which were then left upon it, very indefinite. We did not observe any solid beds retaining the glacial striæ, so that we have not the benefit of their evidence to point out the direction from which the drift came. In my reports for the past four years, I have pointed out the fact that in the extensive region which has come under my observation to the north and Glacial striæ.

General S. W. course of drift.

north-west of Lake Superior, the general direction of the glacial striæ is south-westward, and the same course prevails as far east as the Ottawa River. The composition of the drift itself also shews that it has been transported in the same direction, the materials of which it is formed at any given place being derived from the rocks *in situ* to the north-eastward. There is little doubt that the glacial striæ will be found to maintain the same general course for some distance to the north and west of Lake Winnipeg, as they are known to have for a thousand miles to the east, and for several hundred to the southward. At all events, the plains west of Red River and Lake Winnipeg are strewn with the debris of the crystalline rocks of the country east of that lake, and of a line drawn from its northern extremity north-westward to Athabasca Lake, together with many fragments of the limestone which skirt the south-west side of this crystalline belt, and a certain proportion of the ruins of the rocks immediately underlying any locality on these prairies. These facts have an important bearing in tracing any useful mineral which may be found in the drift to its parent source. As is well known, no gold has been detected in the streams forming the sources of the Saskatchewan in the Rocky Mountains, or near their eastern flank, while it has been traced in the North Saskatchewan and its northern tributaries from the neighbourhood of Rocky Mountain House to the Forks. I have been informed by various miners, who have spent much time in exploring, that they have detected fine gold in almost every stream they tried between the two great branches of the Saskatchewan from the longitude of Edmonton to the forks. We found minute specks ourselves at the Elbow of the South Branch, and at one place in the Red Ochre Hills. As far as known, however, the gold appears to be most abundant about Edmonton. It is, no doubt, washed out of the drift, and as there is little probability of its having come from the unaltered strata underlying the plains, it is to be inferred that it has been derived from the crystalline rocks to the north-eastward, probably, somewhere between the Methy Portage and Athabasca Lake. These rocks lie at a distance of only about 250 miles from Edmonton in that direction. Free gold is known to occur in veins in the Huronian rocks to the north and north-west of Lake Superior. The bands of Huronian rocks in all this region run in a south-westerly direction, or at right angles to the general trend of their outline from Lake Winnipeg to Lake Athabasca. Sir John Richardson in his "Journal of a Boat Voyage through Rupert's Land," mentions the occurrence of rocks corresponding with the Huronian gold-bearing bands which have come under my own observation, and from his descriptions it appears probable that they run in belts, having a south-westerly course. I am therefore of the opinion that the gold found about Edmonton is derived from veins in Huronian strata in the neighbourhood of Lake

Plains strewn with drift from N.E.

Source of the gold of the Saskatchewan.

Free gold in Huronian rocks.

Sir John Richardson's notes.

Athabasca, or between this lake and the Methy Portage. The fact of the Huronian rocks running in belts, whose direction nearly coincides with that of the course of the drift (see my reports for 1869–70–71 and 72) would account for its somewhat local distribution.

The boulders and pebbles of the drift throughout the whole region which we examined consist of Laurentian gneiss, granite, syenite, and the crystalline schists of the Huronian series, together with a large proportion of compact buff, drab, and grey limestone. The limestone blocks are much less worn or rounded, as a general rule, than the other boulders. These loose blocks of limestone are found to burn into an excellent quality of white lime, and they were being used for that purpose at Fort Qu'Appelle at the time of our visit. Composition of drift. Limestone blocks.

As far as I could observe on the routes we travelled between Forts Garry and Ellice, boulders or pebbles of Huronian rocks were very scarce, until approaching within 10 or 15 miles of the latter, when they began to be more abundant. The largest boulder of Huronian rock which I observed was one of fine-grained green mica schist about 10 feet in its greatest diameter, lying on the northern slope of the valley a mile or two below the outlet of the lowest of the Qu'Appelle Lakes. Huronian boulders.

We frequently observed large boulders lying in the bottom of basin-shaped depressions on the prairies. At first we supposed that these depressions had been formed by the wind blowing away the finer materials around the boulder, but it often happened that similar boulders near by had not been affected in the same way, and the boulders in basins sometimes lay in situations not exposed to the wind, and on a stiff, resisting, or damp soil. Upon further examination we found the "basined" boulders were frequently polished or shining, and we came to the conclusion that the depressions had been excavated by the feet of the buffalo during repeated visits for the purpose of rubbing their horns, although these animals have long ceased to frequent some of the localities in which these depressed boulders occur. Boulders in basin-shaped depressions.

OBSERVATIONS ON THE GEOLOGY OF THE CANADIAN ROUTE FROM LAKE SUPERIOR TO RED RIVER.

My report for 1872 contains an account of my observations on the geology of this route from Thunder Bay as far as Sturgeon Lake, and of the Lake of the Woods, with notes on the rocks along Rainy River, and the road from the north-west angle of Lake of the Woods to Fort Garry. In that report (page 96) it is stated that Laurentian gneiss, running in a west-south-westerly direction, extends from a point on the south shore of Lac des Mille Lacs, about four miles east of Barrel Portage, all along the chain of lakes which this route follows as far as Sturgeon Lake. Mica schist begins near the outlet of Sturgeon Lake and continues along the Previous report. Mica schist between Sturgeon and Cross Lakes.

route as far as Cross Lake. The Maligne and Island Portages occur in this interval. The mica schist appears to be all of the same character. It is moderately coarse-grained, and has a white shining appearance with black specks on fresh fracture, and often holds small hard patches or pebbles of a granular quartzose character, like sandstone. At the Maligne Portage the run is a little north of west, and the bedding or cleavage about vertical, but further on it becomes about W.S.W., and the dip, which is northward, diminishes to 60° at Island Portage and 45° at Cross Lake. Around this lake the mica schist becomes much mixed with reddish granite in the form of veins and intruded masses, the proportion of granite increasing in approaching Nequaquon Portage, at the western extremity of the lake. In the western part of Cross Lake nearly all the points and islands are formed of the granite. At Nequaquon Portage the rock consists of a dark grey mica schist, interstratified with gneiss, the latter prevailing towards the west end of the portage (four miles in length) where it has entirely replaced the former.

Reddish granite of Cross Lake.

Nequaquon Portage.

The run of the stratification at this portage was changed to N. 45° W. with a north-easterly dip. At the west end of Nequaquon Portage we come to the lake of the same name, which lies about north and south, and receives the Vermilion River from the southward. Leaving Nequaquon Lake, we pass down about a mile and a half of river, then through a small lake and a narrow channel, and enter Namakon Lake, which discharges by Kettle Falls into Rainy Lake. The rocks along the route from Nequaquon Portage towards Kettle Falls consist partly of gneiss and partly of a dark coarse splintery shining mica schist, to a point on Namakon Lake, about six miles west of the Narrows by which we entered it. From this point to Kettle Falls gneiss appears to be the only rock. Between Nequaquon Portage and the above point on Namakon Lake the run of the rocks varies in different places to every direction between south and west. Along the east side of Naquaquon Lake, and approaching the main body of gneiss in the western part of Namakon Lake, the gneiss and mica schist are interstratified with each other, while between the two lakes the rock consists of mica schist alone, with some veins and masses of granite. The mica schist of this locality appears to belong to a northward spur of the Cross Lake band. Proceeding westward from Kettle Falls through Rainy Lake, gneiss continues to prevail for about twenty miles. Kettle Falls derives its name from pot-holes or "kettles" worn in the rock at the edge of the river. The gneiss at this locality holds micaceous bands and intruded masses of coarse reddish-grey granite, and runs S. 60° W., the dip being vertical. Further west, on the shores of Rainy Lake, the strike of the gneiss varies from S. 60° W. to S. 40° W.

Namakon Lake to Kettle Falls.

Gneiss.

Mica schist.

Rainy Lake.

As mentioned by the late Dr. Bigsby (Geol. Journal, vol. X.), a broad band of schists, having the character of those of the Huronian formation,

Huronian band.

crosses the central part of Rainy Lake. This appears to be the same band which follows the Seine River, and is probably also identical with the one which crosses Brush Creek on one of the routes explored the previous season (see report for 1872). The Indians at Fort Frances manufacture pipes from a soft grey slate which occurs on the long point between the mouths of the Manitou and Seine Rivers. Mr. Robert Pither, the Indian agent at Fort Frances, showed me specimens of light-coloured granular iron pyrites, which he informed me were taken from a thick band in the same locality as the pipe-stone. I was shown a specimen of coarse silvery quartzose mica schist, which is said to occur *in situ* in the above neighbourhood. Mr. Pither likewise exhibited to me a sample of copper pyrites in quartz from a vein on Rainy Lake, but he was not certain of the exact locality at which it occurs. He confirms the account of Mr. S. J. Dawson and others as to the occurrence of Huronian schists along the Seine River. The rock at the Falls of the Rainy River, at Fort Frances is a massive grey granitoid gneiss. Gneiss is also seen on the river, about a mile below Fort Frances, and again at about ten miles. An exposure of massive looking rocks, apparently Huronian schists, occurs at the mouth of Rapid River, which joins the Rainy River from the southward, about fifteen miles from Lake of the Woods. In my report for last year it was mentioned that Huronian schists occur at the Long Rapids at Rainy River. These were found to have a westerly strike, with a southerly dip of about 45°. The banks of the Rainy River, except in approaching Lake of the Woods, are generally from fifteen to twenty feet high, and are composed of clay and drift materials, in which pebbles and boulders of a yellowish-grey limestone are plentiful. There is reason to believe, however, that under these superficial deposits a broad band of Huronian rocks crosses the lower section of the river.

Pipe-stone.

Iron pyrite

Silvery mica schist.

Copper pyrites.

Huronian schists on Seine River.

Gneiss at Fort Frances.

Huronian rocks on Rainy River.

In going from the mouth of Rainy River to the north-west angle of the Lake of the Woods, we had several opportunities of examining the rocks on the way, but as no correct map of the lake exists, it is difficult at present to describe the precise position of our observations, all of which prove to be confirmatory of the general description of the geology of the Lake of the Woods, contained in my report for last year (1872.) Our course from the mouth of Rainy River was north-north-eastward between the large islands nearly to the main shore opposite, and thence west-north-westward to the North-west Angle. Following this course, the rocks observed upon the islands consist of Laurentian gneiss to a point between thirty-five and forty miles from the mouth of Rainy River, and about twenty-five from the entrance to the North-west Angle. On the large islands the gneiss runs about north and south, but towards the end of the above distance the strike is nearly east and west, but it varies to other directions in the interval. On an island at the above distance the rock

Notes on the geology of Lake of the Woods

is a rather coarse, green, glistening mica schist with finer bands of a lighter green colour containing a little dolomite and marked by rusty spots on the surface. The stratification is vertical and runs N.75° W. Gneiss was observed close to the southward. Proceeding towards the North-west Angle, Huronian schists, striking to the south-westward and having a north-westward dip, were observed upon all the islands to within six or seven miles of the entrance to that inlet. The islands and points in this latter interval shew gneiss, granite and Huronian schists, so mingled with each other as to require an accurate topographical survey before they can be satisfactorily mapped or described. (See also my report for 1872, page 104.)

Geological map.

The accompanying map on a scale of twenty-five miles to an inch, illustrating the geology of the whole country north of Lake Superior, from the Michipicoten River to Lake of the Woods, as far as it is yet known, will serve to shew the positions, dimensions, &c. of a large number of lakes, rivers and other geographical features, first surveyed or located by myself and referred to in my reports for the past four years, and which are not represented on any maps yet published.

I have the honor to be, sir,

Your obedient servant,

ROBERT BELL.

GEOLOGICAL SURVEY OFFICE,
Montreal, May 1st, 1874.

APPENDIX TO MR. BELL'S REPORT.

BY

MR. CHRISTIAN HOFFMANN.

ANALYSES OF LIGNITES.

Proximate analyses have been made of seven samples of the lignites collected by Mr. Bell in the summer of 1873. As they had been kept for months in the laboratory they may regarded as having been thoroughly air-dried. The results are as follows :

I. " Lowest Seam, Middle Bluff, Dirt Hills, six feet."

Description :—Slight ligneous structure perceptible ; exfoliated ; fracture sub-conchoidal ; colour black ; lustre shining resinous ; streak brownish. The specimen was slightly coated with clay, which had also permeated the fissures.

This lignite was but very slightly disintegrated after twenty-four hours' immersion in water ; the latter assumed a pale straw colour. Analysis gave—

	Slow Coking.	Fast Coking.
Fixed carbon	47.00	44.78
Volatile combustible matter	33.74	35.96
Water	15.50	15.50
Ash	3.76	3.76
	100.00	100.00
Ratio of volatile to fixed combustible	1 : 1.39	1 : 1.24

Slow coking gave a pulverulent coke, shewing a slight disposition to sinter. By fast coking a portion of the material was converted into a friable coke.

The ash had a light yellowish-brown colour, and agglutinated slightly at a bright red heat.

II. "Seam three feet thick, quarter way up E. Bluff, Dirt Hills."

Description :—Rather friable; splits in laminæ; colour almost black; fracture sub-conchoidal and having a resinous lustre; streak almost black. The specimen was soiled with clay which had also permeated the fissures.

This lignite became disintegrated after a quarter of an hour's immersion in water, colouring the latter pale brownish-yellow. Analysis gave :—

	Slow Coking.	Fast Coking.
Fixed carbon	40.24	39.38
Volatile combustible matter	34.61	35.47
Water	17.53	17.53
Ash	7.62	7.62
	100.00	100.00
Ratio of volatile to fixed combustible	1 : 1.16	1 : 1.11

Both slow and fast coking gave a pulverulent coke, which by the first method shewed a slight disposition to sinter.

The ash was of a very pale brownish-grey colour, and did not fuse at a bright red heat.

III. "Second Seam, up Middle Bluff, Dirt Hills."

Description :—Slight ligneous structure perceptible; tolerably tough; colour dark brownish-black; fracture sub-conchoidal; lustre shining resinous; streak brownish. The specimen was slightly coated with clay, which also had permeated the fissures. This lignite was but very slightly disintegrated after twenty-four hours' immersion in water, the latter becoming just perceptibly coloured. Analysis gave—

	Slow Coking.	Fast Coking.
Fixed carbon	41.18	40.16
Volatile combustible matter	36.87	37.89
Water	16.69	16.69
Ash	5.26	5.26
	100.00	100.00
Ratio of volatile to fixed combustible	1 : 1.12	1 : 1.06

By slow coking about half the coke had sintered, but readily crumbled at the touch; fast coking gave a pulverulent coke. Ash very pale yellowish-grey, and slightly agglutinated at a bright red heat.

IV. "Fourth Seam, Middle Bluff, Dirt Hills."

Description:—Colour dark brownish-black; somewhat friable; fracture uneven, of a black colour and resinous to shining resinous lustre; streak brownish. This lignite, immersed in water, became disintegrated in a quarter of an hour, the water assuming a reddish-brown colour. Analysis gave:—

	Slow Coking.	Fast Coking.
Fixed carbon	39.96	39.76
Volatile combustible matter	33.07	33.27
Water	19.33	19.33
Ash	7.64	7.64
	100.00	100.00
Ratio of volatile to fixed combustible	1 : 1.21	1 : 1.19

Both slow and fast coking gave a pulverulent coke which by the first method shewed a slight disposition to sinter.

The ash had a very pale yellowish-brown colour; at a bright red heat it agglutinated somewhat.

V. "Seven feet lignite and clay, Bare Hill, Dirt Hills."

Description:—Slight ligneous structure perceptible;—tolerably tough; colour almost black; fracture sub-conchoidal; lustre resinous; streak brownish. The specimen was slightly coated with clay, which had also permeated the fissures.

This lignite after twenty-four hours' immersion in water was but very slightly disintegrated, the water becoming just perceptibly coloured. Analysis gave:—

	Slow Coking.	Fast Coking.
Fixed carbon	47.20	45.32
Volatile combustible matter	34.76	36.64
Water	14.80	14.80
Ash	3.24	3.24
	100.00	100.00
Ratio of volatile to fixed combustible	1 : 1.36	1 : 1.24

By slow coking the resultant coke had very slightly sintered; by fast coking a portion of the material was converted into a friable coke.

Ash pale brownish-yellow, and slightly agglutinated at a bright red heat.

VI. "First Hill, Woody Mountain, Lowest Seam."

Description:—Ligneous structure very distinct; very tough; colour dark brownish-black to black; fracture sub-conchoidal; lustre shining resinous; streak brownish.

This lignite was apparently but little affected by a twenty-four hours' immersion in water; the latter was scarcely perceptibly coloured. Analysis gave :—

	Slow Coking.	Fast Coking.
Fixed carbon	46.98	43.07
Volatile combustible matter	37.60	41.51
Water	12.26	12.26
Ash	3.16	3.16
	100.00	100.00
Ratio of volatile to fixed combustible	1 . 1.25	1: 1.04

By slow coking about half the coke had sintered; it, however, readily crumbled at the touch; fast coking gave a pulverulent coke.

The ash had a pale greyish-yellow colour, and agglutinated slightly at a bright red heat.

VII. "First Hi!l, Woody Mountain, Thickest Seam."

Description :—Ligneous structure tolerably distinct; some portions modertely tough, others friable; colour dark brown, sometimes approaching reddish-brown, at other times almost black; fracture uneven; lustre resinous; streak brownish.

This lignite became disintegrated after a quarter of an hour's immersion in water, falling into a coarse powder, the water assuming a brownish colour. Analysis gave:—

	Slow Coking.	Fast Coking.
Fixed carbon	38.95	37.57
Volatile combustible matter	37 73	39.11
Water	18.61	18.61
Ash	4.71	4.71
	100.00	100 00
Ratio of volatile to fixed combustible	1: 1.03	1 : 0.96

Both slow and fast coking gave a pulverulent coke, which by the first method shewed a slight disposition to sinter.

The ash had a very pale brownish-grey colour and did not agglutinate at a bright red heat.

None of these lignites are as good as the brown coals brought by Mr. Selwyn from the Saskatchewan, but resemble more closely those collected in the Souris Valley by Mr. J. M. Dawson of the Boundary Commission. On account of the readiness with which they disintegrate on exposure they should be employed as soon as possible after being mined.

CHRISTIAN HOFFMANN.

REPORT

ON

GEOLOGICAL EXPLORATIONS IN BRITISH COLUMBIA,

BY

MR. JAMES RICHARDSON,

ADDRESSED TO

ALFRED R. C. SELWYN, ESQ., F.R.S., F.G.S.,

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

Instructions. SIR,—Early in May last I received your instructions to again proceed to British Columbia, for the purpose of continuing and extending the geological explorations, which were made there during the two preceding seasons of the coal deposits and other formations on Vancouver Island, as well as on several of the neighbouring smaller islands in the Strait of Georgia.

Leave Montreal. In carrying out these instructions I left Montreal on the 27th of May, and reached San Francisco on the 3rd of June. I there embarked on board the mail steamer Prince Alfred, which left on the 5th, and reached Victoria on the 11th of June.

Leave Victoria. Having hired men, purchased provisions, and made a few necessary additions to the equipment and camping material which were left at Victoria last fall, we embarked on the 17th of June on board the Dominion steamer Sir James Douglas, commanded by Captain Clarke, and arrived on the morning of the 19th at Deep Bay, about 120 miles from Victoria.

Acknowledgement of assistance. I may here again express my obligations to Captain Clarke, not only for his courtesy and attention while on board, but also for his many subsequent acts of kindness, especially in landing and embarking me, occasionally under considerable difficulty, on different parts of the shores of Vancouver and of other islands in the straits, and for his great care in transmitting packages to and from Victoria.

Measurements. Immediately on our arrival at Deep Bay, field work was commenced. A few measurements were made through the woods; but on account of the heavily timbered character of the country and the uniformly thick covering of drift, the beds of streams, which had cut through this drift and exposed the underlying coal rocks, were generally taken advantage of for this purpose.

With the exception of an excursion from Comox to the Union Coal Mine, and thence to the mountains south-east of Puntledge Lake, the work of the season on Vancouver Island was confined to a district extending from Nanaimo north-west, fifty-six miles to Baynes Sound Coal Mine, and south-east, sixteen and a half miles to Oyster Harbour. It was also extended to some of the islands in the Strait of Georgia, and to a few points on the main-land of British Columbia. Towards the end of October, the frequent rains rendered a continuance of field work unprofitable, and on the 30th of October I left Nanaimo by the Sir James Douglas and arrived next day at Victoria. Area examined.

Return to Victoria.

My attention was then devoted to the repacking of specimens, and five boxes of fossils, minerals and rocks were forwarded to Montreal. The tents and sails were dried, and the camp equipment thoroughly cleaned and stored at the office of the Canada Pacific Railway, while the boat was given in charge of the Hudson's Bay Company, and placed under cover on their premises. The whole of these materials may be valued at about $100, and will be available for next season's exploration. I finally left Victoria on the 13th of November, and arrived in Montreal on the 26th of the same month. Disposal of equipment.

GEOLOGICAL FEATURES.

Those portions of the coal-bearing formation of Vancouver Island which were examined and reported on in 1871 and in 1872 were divided into two subordinate troughs; the north-western being described as the Comox, and the south-eastern as the Nanaimo coal-field. (Report of Progress 1872, page 34.)

In the former the area examined in 1872 extended from Brown's River, a tributary of the Puntledge, on the north-west, to Sable River on the south-east, on which the Baynes Sound Coal Mine is situated, and it also includes Denman and Hornby Islands. Although measurements were made in 1872 along the coast from the river Sable to beyond the Qualicum River, none were then made inland; and it was therefore necessary to ascertain the extent of the coal-bearing rocks in that direction. With this object in view, four lines of measurement, of from five to six miles each, were made through the woods from the coast between Sable River and a point to the north-east somewhat beyond Deep Bay, and extending south-westerly to the Beaufort Range. Measurements were also made along the trail mentioned in the report above cited, page 52, as leading across the island to Alberni. These measurements were extended around and to some distance beyond Horne Lake, and others were made from Horne Lake to Mount Mark and down the Qualicum River, in all about twenty miles The next traverse was made up the Little Qualicum Area examined in 1872. Measurements from the coast to the Beaufort Range.

River, which is nearly six miles south-east of the Qualicum River, and though locally known as Little Qualicum is really many times larger than the Qualicum. On account of the difficulty of penetrating the thick woods along its banks, and the only exposures of the rocks being in the bed of the stream, it was ascended by wading in the clear cold water, which is from one to four feet deep; and in this manner a point was reached estimated to be from six to seven miles south-west from its mouth.

Traverse of the Little Qualicum River.

The mouth of the Little Qualicum as represented on the published charts is half a mile inland, and this error gradually increases till at a little more than half a mile to the south-east the shore line as laid down on the charts is more than a mile inland. Thence the error gradually diminishes to North West Bay, the shores of which are correctly represented.

Little Qualicum to Englishman's River.

Measurements were made along the coast from the Little Qualicum River to Englishman's River, a distance of about ten miles; and the examination of the coast was continued, without measurements, to North West Bay, where the south-eastern extremity of the Comox coal area is reached. From this point following around Nanoose Harbour and to Departure Bay, where the north-western boundary of the Nanaimo coal area comes upon the coast, the shores are occupied by crystalline rocks, all of which were examined in detail.

In the neighbourhood of Nanaimo several measurements were made in addition to those of 1872; one being about eight miles in length, from Nanaimo Harbour to a point bearing S. 11° W, on the Nanaimo River. The coal-bearing strata were likewise examined along the coast from Nanaimo south-eastward to Dodd Narrows, and thence to Boat Harbour, Chemanis Bay and to and around Oyster Harbour, which, as already stated, is sixteen and a half miles south-east of Nanaimo, though the distance, following the coast, is probably more than double. Newcastle, Protection, Light House, Gabriola, Mudge and Flat Top, as well as several smaller unnamed islands within the Nanaimo coal area, were carefully examined. Besides these, others in the Strait of Georgia, composed mostly of crystalline rocks, were also examined in considerable detail. The most north-westerly and the largest of these are Texada and Lasqueti. Between these, in the Sabine Channel, a number of small islands were examined, as well as the Sisters to the west of Lasqueti, and Jenkins, Sea Egg and Sangester to the south of it. The small islands in the Ballinac Channel, known as the Ballinacs, Mistaken, Gerald, Douglas, the Yeo, and Winchelsea groups, Southey and Maude, were also visited and examined.

Islands examined.

To the south-east of Nanaimo the coal-bearing strata are much more contorted and folded than they are either at Nanaimo or in the Comox coal-field; and before the structure of this part of the Nanaimo field can be correctly defined, further and more extended examinations are

required; and you have accordingly thought it desirable that before attempting to do so I should employ another season in the investigation. This it is hoped will be sufficient for the purpose, and in the mean time, while the details of the structure will be deferred for a future report, the minerals of economic value and the fossils which were met with during the past season will be now described. Further examination required.

Considerable time and attention was devoted during the season to the collection of fossils with a view of aiding as much as possible in the identification of the different groups of strata within the area. Collections were made at the following localities from beds belonging to the productive coal measures, Division A of the Report of 1872 :— Collection of fossils.

1. In North West Bay, about ninety specimens of plants and animals.

2. In a shallow bay immediately north-west of the latter, a small collection.

3. From the east side of Newcastle Island, a small collection of fossil leaves.

4. From the west side of Protection Island, a larger similar collection.

5. From the east side of Protection Island, fossil shells.

Collections were also made as follows from beds which are supposed to represent the Lower Shales, Division B of last year's report:—

1. From about two miles and a-half up the Nanaimo River.

2. From the coast a short distance to the north-east of Dodd Narrows.

A few specimens were procured from the productive coal measures at Nanaimo, and also at about ten miles up the Nanaimo River.

From the rocks which in the report of last year were described under the head of Crystalline Rocks, fossils were collected this season at the following places :—

1. The shores of Horne Lake.

2. From the coast near Schooner Bay, between North West Bay and Nanoose Harbour. The fossils, which are poorly preserved, were found here in light grey limestone and in bands of black slate, interstratified with the limestone, and both associated with black hornblendic rock with epidote in small strings. The limestone occurs in beds of from three to five feet thick, which are largely intermixed with masses of beautifully crystalline tremolite, of a yellowish-white colour, and occasionally shewing specks of graphite. These rocks strike with the coast and dip inland at high angles. Fossils in crystalline rocks. Limestone with tremolite.

3. From the Ballinac Islands. These islands, two in number, were carefully examined and a tolerably good collection of fossils was secured. As the relation of the fossiliferous beds to the other rocks with which they are associated is of considerable interest, I have selected the following section which is exposed on the larger island at the southern extremity of its eastern shore, and in which these sections are well exhibited. The The Ballinac Islands.

rocks have been laid bare by the action of the sea, and there is a continuous exposure of every part of the section for from 50 to 60 yards in length on the strike of the beds; the dip being S. 58°, W. < 58°. The section is given in descending order.

Section on the Ballinac Islands

	Feet.	Inches.
Epidotic rock, the bedding not well defined	15	0
Pinkish-red bed. This bed is regular and its contact with the overlying bed is well defined	0	6
Epidotic rock, regular and well defined throughout	0	9
Pinkish-red rock passing into epidotic rock, the former from three to four inches, and the latter from 22 to 23 inches thick, the whole very regular	2	2
Epidotic rock, regular throughout	1	8
Green fine-grained diorite passing into epidotic rock; one to two inches of the former and nine to ten inches of the latter	1	0
Red limestone with obscure encrinite stems	0	6
Epidotic rock, very uniform and regular in character throughout	2	3
Reddish very pure limestone in beds of from two to eighteen inches thick, holding well defined fossils stems of encrinites, corals, and brachiopods	50	0

Immediately below the rocks in the above section there is a thickness estimated at from 150 to 200 feet of grey limestone, in some parts interstratified with fine-grained black slate, which seems occasionally to pass into a dark fine-grained dioritic rock. In the limestones numerous silicified fossils are met with, and a single specimen of a portion of a large *Gyroceras* was found in the black slate.

Silicified fossils.

These fossils, which are not well preserved, have been examined by Mr. Billings, who has supplied me with the following note on them:—

"1. Fragments of a small coral, apparently a *Zaphrentis*.

2. Fragments of a large *Spirifer*.

3. The impression of one side of a *Gyroceras*. This specimen was from the black slates.

Age of the rocks.

The age of the rocks is either Carboniferous or Permian; most probably the former."

ECONOMIC MATERIALS.

Coal.

Coal.—Beds of coal not previously noticed were observed during the season at the following localities, given as they occur from north-west to south-east:—

1. In the Comox area, on a small brook about one and a-quarter miles south from Fanny Bay. This seam is only three inches thick.

2. On the Nanaimo River, at a point about 8 miles S., 15° W. from Nanaimo Harbour. This is the only workable seam seen during the season. It is from three feet six inches to four feet thick, of good clean coal, and rests on a bed of black carbonaceous shale with impressions of plants Above it is an exposed thickness of ten feet of brown and grey

sandstone, in beds of from six inches to three feet in thickness; the dip of the beds is N. 71° E.

3. On the north-west end of Protection Island there is a small seam of good clean coal of from one to three inches thick. Protection Island.

4. On the same island about the middle of the south-west side, a seam of similar quality and from three to four inches thick was observed.

5. About half-way up Oyster Harbour, on the north-east shore, a seam of not more than half an inch thick is exposed. Oyster Harbour

In July last Mr. John Jessop, superintendent of schools in British Columbia, sent me a sample of coal from the mainland, accompanied by a note in which he states that the sample was taken from a seam recently discovered in the Chilliwack district about one mile from the Chilliwack River, and less than five miles from the Fraser; but that the seam had not been sufficiently examined to ascertain its thickness or extent. The sample has been examined by Dr. Harrington with the following results:— Chilliwack River.

" A clean, bright, bituminous coal. By rapid coking it gave,

Analysis by Dr. Harrington.

Volatile matter . . .	35.73
Fixed carbon . . .	63.86
Ash	0.41

" It coked, but the coke was non-coherent and brittle. The remarkably small amount of ash which it contained was of a dark red colour."

Iron Ore. On the south side of Texada Island, about three miles northwestly from Gillies Bay, and about seventy paces from the shore, a small exposure of magnetic iron ore was met with, associated with a coarse-grained epidotic rock, and grey diorite. Immediately north of this exposure the ground rises steeply to about 450 feet above the sea. Here on the eastern and south-eastern slopes of the hill, for 150 feet down, and extending from 200 to 250 feet in length, is an exposure of rich magnetic iron ore. On the out-crops facing to the north-west the ore-bed which dips from S. 58° E. to E. $< 25°—30°$ is seen to be from twenty to twenty-five feet thick, and to rest on grey crystalline limestone, with which, for about two feet down, are interstratified bands of ore, of from half an inch to one inch in thickness. The hill still rises to the north and north-east, but along the flank, and at about the same elevation, in a northwesterly direction for nearly a mile, the ore is occasionally seen, and in one place there is a continuous exposure of it for about 250 feet, the bed apparently varying in thickness from one foot to ten feet. In the concealed intervals its course appears to be indicated by a coarsely crystalline epidotic rock carrying ore in places, but with the grey limestones apparently overlying it to the north-east, and the grey and green dioritic rock beneath it to the south-west. Where the ore-bed is exposed in this part of the hill a similar arrangement of the beds is observed, and what

Iron ore, Texada Island. Crystalline limestone. Epidotic and dioritic rocks.

here appears to be the base of the limestone exhibits interstratifications of ore similar to those described at its summit in the first exposure. An overturn dip is probably the cause of the apparent differences in the arrangement of the beds. In a north-easterly direction from the first noticed exposure for a quarter of a mile no ore is seen, after which it is again found, at first in irregular patches mixed with epidotic rocks, and then, its course becoming more northerly, for more than half a mile the bed presents an irregular surface exposure of from 600-900 feet of nearly pure ore. In this part the dip could not be ascertained with certainty, and I am therefore unable to estimate the thickness of the ore. Loose pieces of limestone with interstratified ore-bands were found on the west side, while to the east the ore is bounded by grey and green dioritic rocks.

Thickness of the ore-bed.

Circumstances did not admit of my remaining on the island long enough to trace the continuation of this valuable deposit of iron ore. Mr. Henry Trim, of Howe's Sound, however, who has explored the island, informed me that the ore is to be seen occasionally in considerable exposures to near the north-east coast of the island, a further distance of more than three miles.

These iron ores could scarcely be more favourably situated than they are, either as regards mining, smelting or shipment. There is deep water close to the shore, and wharves might be easily and cheaply constructed, at which vessels could always load in safety, except during the heavy south-east winds which occur occasionally from the middle of September to the end of March. But during these, Gillies Bay, only three miles distant, would afford a safe and convenient harbour of refuge. There is also another harbour at the north end of the island about seven miles distant which would afford shelter in all weather. The site of the ore is eighteen miles from Comox Harbour, twenty-one miles from Deep Bay, and about twenty-three miles from Fanny Bay. These are all good and safe harbours, and are only a short distance from the productive coal-seams of the Comox area. In the event of charcoal being required for smelting the ore, abundance of wood suitable for making it can be procured on the island.

Safe Harbour

Charcoal.

Iron ore is reported to occur also in the following localities:

1. Fifty yards from the Yale and Cariboo waggon road, up a ravine half a mile below Nicoameen in the Lytton district. A sample of this ore was given me by J. W. McKay, Esq., Chief Factor in the Hudson's Bay Company's service at Victoria. It is a magnetic ore, and is stated to occur in a vein eight feet in thickness.

2. About one mile up the river at the head of Knight's Inlet, on the left bank, and about 1,200 feet up the mountain. A specimen of this ore,

and the foregoing particulars, were given me by Mr. Alexander Donaldson, of Victoria.

3. Six miles west from Menzie's Bay, Vancouver Island, near Seymour Narrows. I did not learn the extent of this deposit, but it is said to be considerable, and is close to some of the coal seams of the Comox area.

4. On the west side of Fitz Hugh Sound, at the entrance to River's Inlet.

5. Iron ore is said to occur on the shores of a bay to the south-east of Cape Commerell, at the north-west end of Vancouver Island.

Limestone.—The cliffs of limestone which form part of Mount Mark above Horne Lake are mentioned in the Report of for Progress 1872–73. It is there stated, page 53, that " reaching the west side of Horne Lake, and looking northward to Mount Mark, a drift-covered surface rises between 300 and 400 feet above the lake in the distance of about a quarter of a mile, and from this starts up a wall of limestone with an almost perpendicular face, presenting a thickness of probably 1200 feet, which is again capped by a great mass of brown-weathering diorite." A great variety of excellent ornamental marbles, suitable for almost all purposes, could be procnred from these limestones. They are all more or less crystalline, and of white, whitish, dove-grey and bluish colours, but none of the beds, so far as observed, are sufficiently white and fine-grained to afford statuary marble. As a material for building purposes it could not be surpassed as regards durability and the size of the blocks which could be obtained. Some of the beds present faces of from 30 to 50 feet in breadth, without, so far as could be seen, a single flaw or crack. The Qualicum River, which discharges Horne Lake, would afford any amount of water-power—except, perhaps, in unusually dry seasons, during a part of the months of August and September—for driving all the machinery required for cutting, dressing and polishing the marble. The limestone cliffs are from a mile and a-half to three miles from the outlet of the lake, twelve chains below which is the first fall, of about 30 feet. In the next five chains the river falls about 40 feet, and nine chains further down there is a fall of 25 to 30 feet in a length of about one chain. The next and last fall of any importance is 43 chains still lower down. Here the stream is divided into three branches and falls about 100 feet. In the centre channel the lower 60 feet is an unbroken perpendicular fall, away in a deep recess or *canon*, between walls, only a few feet apart, of dark, nearly black, dioritic rock.

Limestone.

Water-power.

The constant and regular supply of water in this stream, together with the natural reservoir at its head, and the facilities for utilizing it at so many different levels, afforded by a fall of about 200 feet in a mile, are features which render it pre-eminently valuable as a water-power. The last fall is a little more than four miles from the coast, at the mouth of the

river, but the shallowness of the water and the exposed position render it an indifferent harbour. Deep Bay, however, further west, although small, is one of the best harbours on the coast, and is only eight miles north-west from the lower falls.

Deep Bay.

At the north-west end of Texada Island limestones are well exposed on the coast from one mile south of Point Marshall, around the north-west end, and thence along the north-east shore for about four miles south-east, or altogether for a distance of about seven miles. These limestones are similar to those of Mount Mark, being of white, whitish dove-grey, and bluish colours. Some of the white variety is, however, finer grained, and in this respect, as well as in colour, more nearly approaches the character of fine statuary marble, but the beds are here traversed by numerous joints running in different and irregular directions, so that it would seldom be possible to obtain sound blocks of large dimensions, though there are a few places where blocks might be obtained sufficiently large for ordinary building purposes.

Timber.

Timber, etc.—On the Donaldson River, which rises in the Beaufort Mountains and falls into the Gulf of Georgia about three miles west to Deep Bay, white pine, *P. strobus*, is more abundant at 800–1,400 feet above the sea than it is at lower levels. The soil on and near the Donaldson River at the above elevation is of a mixed clayey and sandy character, and here white pine is very abundant and of large size. The following are the dimensions of one tree of average size which was measured as it lay on the ground. Diameter, three feet from the root, two feet, and at 105 feet, eighteen inches. Total length 175 feet—105 feet without a branch. Many of the trees are considerably larger, and more than 200 feet in height. White pine timber is worth nearly double the value of Douglas pine, *Abies Douglassii*, on account of its superiority for finishing purposes, and it may be useful to persons seeking for it to know that it will probably be found in greater abundance and of better quality at the above elevation than at lower levels.

With regard to the agricultural capabilities of the country examined, I have nothing to add to the information given in the reports of 1871-72 and 1872-73. On all of the islands explored during the season the rocky character of the surface renders them wholly unfit for cultivation.

I have the honour to be, Sir,

Your obedient servant,

JAMES RICHARDSON.

GEOLOGICAL SURVEY OFFICE,
Montreal, May 1st, 1874.

REPORT

OF EXPLORATIONS AND SURVEYS IN

FRONTENAC, LEEDS AND LANARK COUNTIES,

WITH NOTES ON THE

PLUMBAGO OF BUCKINGHAM AND APATITE OF TEMPLETON AND PORTLAND TOWNSHIPS, OTTAWA COUNTY.

BY

HENRY G. VENNOR, F.G.S.,

ADDRESSED TO

ALFRED R. C. SELWYN, ESQ., F.R.S., F.G.S.,

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

SIR,—Last summer I continued my work in the counties of Frontenac, Leeds and Lanark, and spent the chief part of my time in a further study of the five important bands of crystalline limestone to which I drew your attention in my last Report, (Report of Progress 1872-1873, p. 160), and to the uppermost of which are related several of the most promising deposits of magnetic iron ore. A considerable time was also spent in examing a number of openings made on veins and beds of apatite or phosphate of lime in the eighth concession of North Burgess, and the positions of upwards of 145 of these were fixed by measurement. Later in the season, I traced out other synclinal forms of phosphate-bearing rocks and crystalline limestone in Loughboro' and Bedford townships, and determined the horizon within which remunerative deposits of apatite might be looked for. During the season, an opportunity was also afforded for examining some mineral deposits of economic interest in the townships of Buckingham, Templeton and Portland in the County of Ottawa, to the northward of Ottawa city, the more important of these are plumbago, phosphate of lime and baryta. For assistance and information received, while exploring in this last named section of country, I would especially acknowledge my obligations to the Hon. Alex. Campbell, Dr. J. A. Grant, F. P. French, J. A. Gouin and A. Walsh, of Ottawa city, and to Capt. A. McNaughton of Buckingham.

Districts Examined.

Acknowledgement of assistance.

The results of the past season's explorations may be given under the following heads:

Distribution of the Crystalline Limestones.

Synclinal Forms of Phosphate Rocks in Loughboro' and Bedford.

Phosphate of Lime in the Eighth Concession of North Burgess.

Plumbago and Phosphate Deposits of Ottawa County.

DISTRIBUTION OF CRYSTALLINE LIMESTONES.

Map.

In a detailed map of this section of country, at present being prepared by Mr. Robert Barlow, the course of each of the five bands of crystalline limestone, through the townships of Olden, Oso, North and South Sherbrooke, Dalhousie and Bathurst, will be laid down. This map will show at a glance the relative positions of these bands, their estimated thickness, and the volumes of the gneisses which separate them. For the present, therefore, the detailed enumeration of the concessions and lots in these townships, through which the several bands of limestone pass will be deferred, and merely a sketch given of the general bearing or run of each. Some of their most distinguishing features will also be noticed, and the distance stated to which they have, respectively, been traced.

Five bands of limestone.

In my last Report, (Report of Progress 1872-1873, page 160), I alluded to five distinct bands of crystalline limestone; they are as follows:—

1. White Lake and Bolton's Creek band.
2. Upper Sharbot Lake, Playfairville and Lanark band.
3. Lower Sharbot Lake, Maberly and Bennet's Lake band.
4. Crow Lake, Rock Lake, and Silver Lake band.
5. Bobs' Lake, Tay River, and Meyers' Lake band.

It is still my opinion that these are distinct bands, and that they represent an ascending sequence in the rock formation of the country. They nearly all present some characteristic features by which they may be identified, and by which one band may be distinguished from another.

White Lake band.

1. The White Lake and Bolton's Creek limestone rests upon a great body of speckled hornblendic or pyroxenic gneiss and greenish hornblendic slate rock. It was continuously traced from White Lake in Olden township, through Oso, following the general course of Bolton's Creek, to the line between North and South Sherbrooke, then along this line into Dalhousie, where, trending more north-easterly, it passes MacDonald's Corners, and thence to Watson's Corners, in all a distance of twenty-four miles. The marked features of this band of limestone are its highly crystalline character, its massiveness, and its clouded grey and white colors. It affords a beautiful building stone, and has been quarried to some extent for this purpose in the township of Dalhousie.

Sharbot lake band.

2. Both above and below the Sharbot Lake band, mica slates occur, and towards its lower portion are interstratified with it. It has been traced from the western extremity of Sharbot Lake in Olden into Oso, and thence through this township in a northerly direction past the head of Silver Lake into South Sherbrooke, where it runs in an easterly direction through portions of the tenth and eleventh concessions.

Entering Bathurst, it turns more north-easterly to the line between this last named township and Dalhousie, which it follows to Playfairville and thence to Lanark village in Lanark township, where its course again is in a northerly direction. The distance from the first noted position of this band on Sharbot Lake to Lanark village is close upon twenty-eight miles. This band is the most marked I have yet met with, not only from its associated mica slates and great volume, but from its uniform banded character. At Playfairville on the Mississipp River, and at Lanark village, this banded character is beautifully seen, the limestone showing alternate layers of white and bluish-grey colors, the latter being of a more silicious character than the former. In my last Report, already several times referred to, this banded limestone was described in some detail. It contains a great quantity of rust-colored quartzite, in layers, lumps and lenticular patches, their cólour being due to the decomposition of the abundantly disseminated grains of pyrites. Scales of graphite are also occasionally met with, but nowhere in sufficient quantity to form a special characteristic. Two or three distinct *fahlbands* also accompany this band, and these may yet be productive of some valuable ores. **Banded character of the limestone.**

3. The Lower Sharbot Lake, Maberly village and Bennet's Lake band, separated from the last named by volumes of black hornblendic slate and quartzose gneiss, has been traced from St. George's Lake, on the boundary line between Olden and Oso, across Sharbot Lake to its outlet, and thence runs to and through the ninth concession of South Sherbrooke, passing to the north of the village of Maberly, and along the north-western shore of Fagan's Lake on the line between the latter township and Bathurst, thence through the entire length of Bennet's Lake, and along the course of the Fall River towards Drummond township; the total distance from St George's Lake in Olden being close upon twenty-four miles. In Drummond township, it runs under rocks of Lower Silurian age. In reality it consists of two or more beds of limestone, separated by bands of feldspathic gneiss and is not marked by any special characteristics. It is, however, accompanied by one or two *fahlbands*, and is associated with an important volume of a greenish speckled hornblendic or pyroxenic rock. **Lower Sharbot Lake band.** **Lower Silurian rocks.** ***Fahlbands.***

4. The Crow Lake, Rock Lake and Silver Lake band of limestone is well marked and important. It is separated from the last by a great volume of granitic gneiss, which is probably not lesst han eight to nine thousand feet thick. From Eagle Lake, in the north-eastern corner of the township of Hinchinbrooke, it has been traced to the head of Crow Lake, in Oso; thence north-eastward to Rock Lake, a small lake situated close to the town line of South Sherbrooke. Entering this last township, it runs through portions of the fifth and sixth concessions, passing a little to the north of Silver Lake, and enters the sixth concession of Bathurst, whence, again trending north-eastwardly, it passes through the seventh **Crow Lake band.**

concession to the eighth concession line, which it follows, in a nearly direct course, to Balderson's Corners, on the line between Bathurst and Drummond townships. In Drummond it immediately runs under a heavy drift, and shortly after is capped by rocks of Lower Silurian age. The distance from Eagle Lake to Balderson's Corners is about twenty-six miles. A remarkable feature of this band is, that it immediately overlies

Magnetic iron ore and apatite

a zone of rock containing magnetic iron ore and deposits of phosphate of lime. These minerals were observed in proximity to this limestone, at Eagle Lake, at Crow Lake, in Bedford and Oso, and again at the Foley and McVeigh lots in Bathurst, in which last locality both have been mined to a small extent. The limestone has also interstratified with it a number of subordinate bands of red feldspathic bands, which separate the whole into a number of unequal parts. The largest calcareous bed does not exceed 150 feet, but the total thickness from the base of the lowest bed of limestone to the top of the highest may be estimated at not less than 2,600 feet. The limestone is coarsely crystalline, and holds in abundance small scales of a yellowish-brown mica, and less frequently graphite.

Bob's Lake band.

5. The Bob's Lake, Tay River, and Meyers' Lake is perhaps the most important band in the whole sequence. It is separated from the last by a great volume of gneissic strata, which has a transverse measurement of over 13,000 feet. This may, or may not, represent the actual thickness of the gneiss, as the strata are all in a nearly vertical attitude, and there is no evidence of any repetition of the beds. The limestone was continuously traced, from the southern extremity of White Lake in Bedford, across Green Bay and Bob's Lake, to the Tay River in South Sherbrooke, and thence along the general bearing of this river, to and across Meyers' or Christie's Lake into the township of Bathurst, where its course is shortly concealed by heavy drift. The distance from White Lake in Bedford to the last position in which the band was noted in Bathurst, is about twenty-two miles. The thickness cannot be less than 2,600 feet, and the limestone differs in a marked manner from either of the four inferior bands. It resembles them in being white, but is much more coarsely crystalline.

Graphite.

Graphite is abundantly disseminated through it in brilliant plates or scales, and there are also layers of white quartzo-feldspathic rock associated with it, which occur both in the form of interstratified beds and irregular masses. This may, for the present, be considered as the highest band of limestone in the series, and it belongs to the synclinal forms which I have yet to bring under your notice as occurring in Bedford and Loughboro'. It is overlaid by a considerable volume of gneissic strata, in which there also occurs a small band of limestone—the Farren Lake band—as noticed (Report of Progress, 1872-73, page 160) but which may be left out of consideration for the present.

Magnetite.

At its base, and also at some distance above it, there are important deposits of magnetic iron ore, a fact which has already been dwelt upon in my previous reports.

SYNCLINAL FORMS OF PHOSPHATE ROCKS IN LOUGHBORO' AND BEDFORD TOWNSHIPS.

These forms give a very irregular outline to the outcrops of the limestones in the townships of Bedford and Loughboro'. So much so indeed, that to describe the course of each in all its windings would not only be tedious, but also occupy more space than is desirable in the present Report. Besides, a glance at the map, already alluded to as being in preparation, will convey a much better idea of the position and form of the synclinals than any verbal description. I shall therefore at present confine myself to some general remarks on their geological position, and describe one or two of the more important of the troughs. The five limestone bands enumerated on page 104 present an undoubted ascending sequence. Their dip is uniform to the south-eastward, and almost invariably at a steep angle, while their lines of outcrop, as we have already seen, have been traced for long distances on the general strike of the rocks. On entering Burgess, Bedford and Loughboro', however, we have no longer a uniform strike and dip, but find one, or perhaps two, of the bands of limestone again and again repeated through subordinate undulations of the strata, and in the synclinals resulting therefrom a still higher series of gneisses, limestones and quartzo-orthoclase rocks is brought in along with extensive deposits of apatite or phosphate of lime. The first synclinal noted and traced is formed by the fifth or highest band of limestone, namely, the Bobs' Lake, Tay River, and Meyers' Lake band, and occurs between the townships of Bathurst, South Sherbrooke and the western portion of Bedford, on the one hand, and North Burgess, North Crosby, and the eastern portion of Bedford on the other. The northern and north-western outcrop of the limestone, stated, on the last page, to have been traced from White Lake in Bedford to Bathurst, is that already described. The southern and south-eastern outcrop, on the opposite side of the synclinal, runs from the foot of Pike Lake in North Burgess south-westward along the north-western shore of this lake into North Crosby, and thence westward, through Crosby Lake in North Crosby, to the town line of South Sherbrooke, whence turning south-westward it reaches the head of Wolf Lake in Bedford, passes by Fermoy Post Office, and, following down the "Old Bedford road," forms a junction with the outcrop at White Lake. It will be seen from the foregoing that this synclinal form is considerably narrowed, between South Sherbrooke and North Crosby, by the east and west trend of the limestone through Crosby Lake; while to the eastward, between Meyers' or Christie's Lake in Bathurst and Pike Lake in North Burgess, and to the south-westward through Bedford, the basin is considerably expanded. The space between the outcrops of the limestone on opposite sides of the

Geological position of the phosphate rocks.

First synclinal.

synclinal in North Burgess on the one side, and Bathurst and South Sherbrooke on the other, is occupied by red and greyish gneiss rocks, and on the town line of Bathurst, in a position which would appear to be towards the centre of the synclinal, red or flesh-coloured calcite, similar in every respect to that occurring with apatite in veins in North Burgess, is found interstratified in beds of thirty feet in thickness and upwards. The south-western portion of the synclinal, namely, that in Bedford, is almost wholly occupied by the limestone, which is kept at the surface through minor undulations, all the way across from White Lake and Green Bay on the west, to Wolf Lake on the east. Up to the present date no phosphate of lime has been found in this trough or basin.

Red calcite.

No phosphate found.

Second synclinal.

The second of these synclinal forms to which I would draw attention is that occurring between the limestone outcrops of Canoe Lake and Devil Lake, in Bedford. Here the limestone is immediately underlaid by garnetiferous gneiss, and overlaid by thinly bedded and banded granite gneiss, and red orthoclase gneiss. This, I take to be the south-western extremity of the North Burgess phosphate basin, as it is immediately on the opposite side of the axis of an anticlinal which has now been traced from Canoe Lake into North Burgess. In this portion of the synclinal in Bedford, phosphate of lime occurs in several places, but as yet has not been much sought after, and no deposits of importance have been brought to light. Between the limestone on Devil Lake in Bedford and Buck Lake in Loughboro', another anticlinal exists which separates the trough in Bedford from the basin or trough described in my last report as occurring between the last-named lake and Opinicon and Rock Lakes in Storrington, namely, the Loughboro' and Storrington phosphate basin, (see Report of Progress, 1872–1873, p. 170 et seq.) This trough, I described as terminating towards the south-western end of Buck Lake, but I have since traced it further westward through Loughboro' as follows: The Buck Lake band of limestone, representing the north-western border of the synclinal, upon reaching the extreme south-western end of Buck Lake, suddenly deviates from its north-easterly and south westerly course, and is carried in a westerly direction to the northward of Otter Lake, a small body of water in Loughboro', situated a few chains to the northward of Gold Lake, where it forms the exposure noted, but unaccounted for by Mr. A. Murray, in his Report of Progress, 1852–53, page 86, where he states that "though the axis of the synclinal form would cross the upper or eastern part of this lake, (Otter Lake) the north shore, from the eastern extremity to the eighth lot, a distance of about two miles, is composed of gneiss, and so is the southern shore on the tenth lot. The western extremity of the lake, however, from the middle of the ninth lot on the south, and of the eighth on the north side, consists of crystalline limestone, which was observed

Extract from Mr. Murrays. report 1852-53.

to extend down the stream emptying the lake, to the middle of the sixth lot. But this mass appears to be too far westward to belong to the synclinal in question, unless it suffers an extraordinary turn in that direction; it appears also to be too far to the eastward for the continuation of the Knowlton Lake band, and it may therefore be an outlying patch." From its position just given on Otter Lake, this band again turns eastward to the head of Gold Lake, across which it runs in a south-eastward direction, forming several islands, and the whole of the eastern shore. On a continuation of this course, it passes to the southern end of Knowlton Lake, where its position has already been noted by Mr. Murray, in his Report just cited. The south-eastern outcrop on the opposite side of the synclinal, the course of which has already been indicated, after running for a short distance to the westward with the Buck Lake outcrop, separates from it, and running to the eastward of Spectacle and Draper's Lakes, and then westward to the south of these lakes, forms an indentation corresponding to the bend on the opposite side of the synclinal at Otter Lake, but of much smaller extent. Beyond this position it again turns to the south-west, enters Eel Lake, and passes beneath its waters to Stoat's Lake, where it runs under rocks of Lower Silurian age. In this south-western portion of the synclinal, namely, between Gold Lake and the head of Eel Lake, the rocks are precisely similar to the phosphate-bearing series of North Burgess, and apatite has been found in a number of places. I would especially note here the occurrence of magnesian limestones, and almost pure dolomites with grains of steatitic pyroxene, and green or yellowish-green serpentine. A similar dolomite also occurs in several places in North Burgess, accompanied by *Eozoon*. **Magnesian limestone dolomites and serpentine.**

This occurrence of magnesian limestones, with serpentine and *Eozoon*, in synclinal forms or basins, at the very summit of the whole rock series in Loughboro' and Burgess, is a point worthy of special consideration; as it will be remembered that the *Eozoon* found in Madoc and Tudor townships, in the county of Hastings, occurred in similar basin forms of rock, and was associated with a great deal of dolomite, in which, however, serpentine was not observed. In the sequence of rocks traced through Olden, Oso, South Sherbrooke and Bathurst, neither dolomites nor magnesian limestones have been observed.

The sudden contraction and re-expansion of these synclinal forms in Loughboro' is due to the existence of a number of east and west dislocations or faults, the true nature of which has yet to be investigated. **East and west faults.**

PHOSPHATE OF LIME IN THE EIGHTH CONCESSION OF NORTH BURGESS.

The numerous deposits of apatite or phosphate of lime, which occur in the eighth concession of the township of North Burgess, from lot A **North Burgess, eighth concession.**

to lot number seven, have now been examined in detail, and measurements made of upwards of one hundred and forty-five openings.*

LOT A.—Commencing with the most easterly of these openings, namely, on lot A, on property owned by Mr. Flaherty, an excavation has been made near the side line between this lot and lot number one, and about twenty chains to the north of the road leading into the Ritchie & Jackson phosphate mines. This opening was about four feet deep, and measured twelve feet in length by eight in width. There is no appearance of a vein, nor even of solid rock, in it, and the phosphate occurs only in loose masses, embedded in a micaceous and pyroxenic *débris*. Previous to the date of my examination, about five tons of a coarsely granular apatite had been extracted. Two other openings on this lot, nearer the road just mentioned, show apatite in pockets, in a similar micaceous and pyroxenic matrix, without any appearance of a vein. Apatite also occurs on other parts of lot A, on ground belonging to Mr. Watts, but has not yet been opened upon.

LOT 1 EAST HALF.—On the east half of lot one, owned by John Watts, the mineral right of which, however, has been sold to Messrs. Morris & Griffin, of Wolverhampton, England, several openings have been made. They are as follows:

Opening No. 1 is ten feet in length, seven feet wide, and fifteen feet deep, on a vein or bed of green massive apatite, which strikes in an east and west direction. This vein or bed varies from one to two feet in width, and is enclosed or bounded by walls of a dark quartzose and micaceous hornblendic or pyroxenic gneiss. From it about fifteen tons of apatite, of a good quality, have been obtained. The position of this opening is close to the side line between lots A and one, and about opposite to the main pit on Mr. Flaherty's property.

Opening No. 2, about half a chain to the N. W. of No. 1, is about 35 feet in length and 6 feet in depth, on a vein or bed which strikes N. 15° E. From it about ten tons of good apatite have been obtained. At the date of my visit no work was in progress; the ground was considerably overgrown and the opening filled with débris.

Opening No. 3 is twenty-five links to the west of No. 2, and is 40 feet in length, in a N. E. direction, 8 to 11 feet wide, and 12 feet deep in the deepest part. It is on a deposit, apparently a bed, which for over fifteen feet averages three feet in width. From the north-eastern end of the opening a spur runs off in a northerly direction. The amount of apatite extracted is, as nearly as I could learn, fifty tons, all of which was of first-class quality. At the time of my visit the bottom of the

*The most important of these openings are correctly laid down on the plan of Mr. Burgess which accompanies the present report.

trench was covered by water and *débris*, and no work was in progress. In opening No. 2, as well as in No. 3, the adjoining rock contained but little mica, and was largely composed of a dark hornblende or pyroxene, and reddish orthoclase feldspar.

Opening No. 4 is about one chain to the N. W. of No. 3. It is a trench thirty feet in length, on a bed of calcite containing crystals of green apatite, and striking in a N. E. and S. W. direction. It has been sunk in one place to a depth of twelve feet, and altogether there have been obtained about three tons of apatite in crystals. This opening had also been abandoned previous to my visit.

Opening No. 5 is a little to the N. W. of No. 4. It is a trench, thirty feet in length, ten to fifteen feet broad, and twenty-five feet deep, on a bed of red calcite parallel with that in No. 4. At the time of my visit it was half filled with water, as no work had been in progress for some time. The apatite occurred in crystals and groups of crystals in the carbonate of lime.

Apatite in calcite.

Opening No. 6 is about one chain to the west of No. 5, and is roughly parallel to it. It is an open cutting, twenty-five feet in length, twelve in breadth, and about thirty-five feet deep at the deepest point, over which a derrick has been erected. At the bottom the vein is said to be over three feet in width for a distance of twelve feet, but as the opening contained about ten feet of water at the date of our examination, I was unable to verify this. Upwards of eighty tons of excellent apatite had been extracted and removed.

Opening No. 7 is just one chain to the south of the derrick at No. 6 It had been sunk on two pockets of apatite to a depth of twelve feet, and three tons of the mineral obtained. No work was being done here during my visit.

Opening No. 8 is a trench running N. 70° W. It is about one chain in length, and is sunk in one place to a depth of twelve feet. The amount of apatite raised is not known. No work in progress.

Opening No. 9 is about two chains N. 80° W. of the derrick at No. 6. It is on a group of three pockets, each of which has yielded from one to two tons of phosphate of lime in crystals. These crystals are embedded in a whitish or pale flesh-coloured carbonate of lime.

Apatite crystals in calcite.

Opening No. 10 is about twelve chains N. 75° W. of the derrick. It is ten feet by four feet, and five feet deep. Here the apatite also occurs in crystals in calcite. The openings Nos. 7, 8, 9 and 10 will probably not lead to anything of importance.

Opening No. 11 is two and a half chains N. 60° E. from No. 10. It is an open cutting of about sixty feet in length, four feet wide, and from four to five feet deep. Towards the centre a pit has been sunk to the depth of twelve feet. This cutting was first commenced for mica, but

was subsequently worked for apatite, about five tons of which were obtained. The apatite occurred in the form of crystals in a matrix of calcite. I observed some large crystals of a dark coloured mica on the ground, upwards of one foot in diameter.

Large mica crystals.

Opening No. 12 is about one chain to the south of No. 11. It is a trench about thirty feet in length, three in width, and from seven to eight feet deep, from which three tons of apatite have been obtained. This opening touches upon the centre line of the lot.

Opening No. 13 is two chains N. 70° W. of No. 1. It is eight feet by six feet, and seven feet deep. The rock at the bottom of the opening is a dark bluish, quartzose gneiss, and the apatite occurred as an irregular layer or patch overlying this floor of rock. About six tons of very good mineral had been extracted.

Opening No. 14 is fifteen feet N.W. of No. 13. It is close upon six feet square, and about twelve feet in depth. The rock at the surface is soft and very micaceous, but in depth becomes very quartzose, and resembles the rock in opening 13. I could not ascertain the amount of phosphate which had been taken from this pit.

Opening No. 15 is one chain north of opening No. 1. It is a ditch eight feet in length, three in breadth, and four feet in depth, from which five tons of apatite were obtained, but is now filled in with *débris* and much overgrown.

Opening No. 16 is about three chains north of the derrick at No. 6. It is nine feet long, six feet wide, and ten feet deep. The surrounding rock is the same pyroxenic variety of gneiss already several times noted, and the apatite occurs in an irregular form, in a matrix of carbonate of lime. The sides of this opening have now fallen in, and there is but little trace of the mineral. I could not ascertain what quantity of it had been obtained.

Pyroxenic gneiss.

Opening No. 17 is only a few feet N.E. from No. 16, and is sunk on a rock of like character.

Opening No. 18 is three-quarters of a chain west of 17. It is eight feet in length, six feet wide, and seven feet deep. The rock is pyroxenic gneiss, and intermingled with it there occurs a good deal of carbonate of lime in pockets and small veins. I could see but little trace of phosphate.

Opening No. 19 is about one chain north of the derrick, and is nearly eighty feet in length, and from four to eight feet wide. It is in a vein or bed of apatite, which strikes N. 60° W. In one place a pit has been sunk on the vein for twelve feet, but the average depth of the cutting does not exceed seven feet. It is not easy to make out the bedding of the surrounding rock, which is a feldspathic granite or gneiss, but in places it appeared to be horizontal. This is a promising deposit, and from it there

there have already been obtained upwards of twenty tons of good marketable apatite.

Opening No. 20 is half a chain west of the derrick. It it a shallow opening, having an area of about 120 square feet, from which about five tons of apatite had been taken. It may be remarked here, that this singular superficial form of deposit is but little understood, and that it is of frequent occurrence.

From the foregoing twenty openings, close upon three hundred and fifty tons of good marketable phosphate of lime have been raised and sent away. During my visit Mr. W. Davis, agent for Messrs. Morris and Griffin, of Wolverhampton, England, was at work with five men, who were raising good apatite, chiefly on opening No. 19.

LOT 1, WEST HALF.—The western half of this lot is owned by E. Flaherty, but the mineral right has been leased by Messrs. Meighen & Morris, of Perth. On it, there are also a number of openings, but only two appear to be of importance.

Opening No. 1 is about ten feet square, and is situated twenty feet from the centre line of the lot, and about one-third way back from the seventh concession line. It is on an irregular vein of green apatite running in a north-westerly direction, through a rock composed of a mixture of pyroxene, feldspar, mica and carbonate of lime. In one corner of this opening, the apatite has a width of over two feet, and altogether close upon twenty tons of mineral have been obtained. A few feet to the westward again, there is another opening, shewing a great deal of a dark-colored mica, with but little trace of apatite.

Opening No. 2 is about three chains S.W. of No. 1. It is eight feet long, four feet wide, and only four feet deep. Here a vein of green apatite was uncovered, striking N. 30° W., with an average width of six inches, from which there had been obtained over seven tons of a very fine quality of apatite.

LOT 2, NORTH-EASTERN HALF.—The north-east half of the second lot in the eighth concession is owned by J. Halliday, and the mineral right by Dr. Wilson and the Hon. A. Morris, of Perth. Here there are six openings.

Opening No. 1 is close to the side line between lots one and two, and just beside Mr. Flaherty's gate. It is about six feet by four, and four feet deep. I could see no apatite, but noted a vein of sulphate of baryta, which appeared to strike N. 10° E. Sulphate of baryta.

Opening No. 2 is half-way between the last and Otty Lake, and is three chains from the side line of lot one. It is eight feet in length, three in width, and over five feet deep. The vein of barytes also traverses this opening, but I could only observe scattered indications of apatite. There is a considerable quantity of white crystalline limestone in the vicinity of both of these openings

Opening No. 3 is near the middle of the half lot, and about half-way between the Ritchie & Jackson road and Otty Lake. It is a trench running N. 70° E., for a distance of seventy-five feet, and is three feet wide and three feet in depth. The only trace of apatite observed was towards the south-west extremity, where a vein of a reddish color, three inches in thickness, appeared to strike N. 70° W.

Opening No. 4 is one chain north of the vein in No. 3. It is a trench, ten feet long, three feet wide, and of irregular depth. In it, apatite occurred at several points, but in very sparing quantity. The enclosing rock is very soft and micaceous, and contains a considerable quantity of pyroxene.

Opening No. 5 is close to the side line, towards the centre of the lot, and is just across the road from No. 3. It is eight feet in length by two in width, and is in a vein of apatite from three to six inches wide, striking east and west. The walls of the vein are very micaceous, and the enclosing rock is a reddish granitic gneiss. Three tons have been raised.

Opening No. 6 is almost upon the centre line of the lot. It is nine feet in length and three feet in breadth, and a little over four feet deep. A vein of apatite traverses it, striking N. 80° W., with an average thickness of six inches; over eight tons of good phosphate have been obtained here.

LOT 2, SOUTH-WEST HALF.—On the south-west half of lot two in the eighth concession, there are upwards of thirty openings. Both land and minerals are owned by the Hon. R. Matheson, of Perth.

Opening No. 1 is near the centre of the half lot and about seventy yards from Otty Lake. The soil has been removed to the depth of four feet, and a vein of red and green apatite exposed, having a width of about six inches, and striking N. 80° E. The country rocks here are feldspathic granite and greyish quartzite. This vein has a promising appearance, and although it is narrow at the surface, may, like many similar veins, expand in depth.

Opening No. 2 is near the centre line of the lot, and about 120 yards from Otty Lake. It is on the side of a hill, which exposes a vertical vein of apatite having a thickness of twelve inches. The side walls are dark coloured and very micaceous, and the surrounding rock is granitic gneiss.

Opening No. 3 is about two-thirds of the way across the half lot. It is eight feet in length, four feet in width and about three feet deep, and is on a vein of green phosphate which strikes N. 10° W., having a thickness varying from three inches to two feet. The surrounding rock is quartzose and granitic, and in places is rust-coloured. Only two tons of apatite had been extracted at the date of my visit.

Opening No. 4 is about eighty yards from the side line of lot three,

and forty yards below the Ritchie & Jackson road. It is three feet by five, and a little over three feet deep. A vein of green apatite is exposed, and traverses the opening in a north-easterly direction, varying from two to four inches in width. The immediately adjacent rock is very micaceous, but the general character of the gneiss on the lot is quartzose and granitic.

Opening No. 5 is also eighty yards from the side line of lot three, but is about fifteen yards nearer to the road than opening 4. Here a vein of coarsely granular green apatite striking in an east and west direction, and from twelve to eighteen inches in thickness, has been stripped for seven feet. The enclosing rock is likewise a quartzose granitic gneiss.

Granular green apatite.

Opening No. 6 is a pit eight feet square, and about six feet deep. It is in the corner formed by the side line of the third lot (McKinley's) and the Ritchie & Jackson road. A vein of apatite crosses the opening diagonally, striking N. 70° W., and is from six to eight inches in thickness, where exposed. The bottom of the pit, however, is covered with stones and *débris*. I observed a considerable amount of a very black mica in large crystals on the eastern side of this excavation. The rock appears to be granitic gneiss of a dark colour. I was informed that, in all, five tons of apatite had been shipped from this vein.

Large crystals of black mica.

Opening No. 7 is about ten feet S. 60° E. from 6, is six feet by four, and four feet deep. A vein of apatite is exposed for a distance of five feet, striking N.W. and averaging at least twelve inches in thickness. The rock is still granitic, with but little mica. One ton of apatite was obtained here.

Opening No. 8 is about ten yards above the road, and eighty yards from the side line of lot three. It is six feet in length, from two to four feet wide, and five feet deep. A vein of apatite with mica, three to four inches wide, is exposed striking east and west. The surrounding rock is soft and very micaceous at the surface, but in depth becomes very hard and difficult to drill.

Opening No. 9 is near the centre of the half lot, and ten yards above the road. Correctly speaking there are here two distinct but very irregular openings five yards apart. These have been made upon a bed or bedded vein, striking in an east and west direction, and averaging ten inches in thickness. This is a beautiful vein, and the apatite is of excellent quality. The soil thrown out of both of the openings abounds with mica, and the immediately underlying rock is a rust-coloured gneiss.

Beautiful vein of apatite.

Opening No. 10 is in the side of a hill, towards the centre of this half lot, and about one quarter of a mile above the Ritchie & Jackson road. It is ten feet in length, four feet in width, and about five feet deep, and exposes a beautiful vein of green apatite, striking N. 75° W. and

Vein twelve to twenty-four inches thick.

varying in width from twelve to twenty-four inches for a length of eight feet. The rock here is granitic in parts, and again appears to be largely composed of a very dark hornblende, with but little mica. Upwards of seven tons of good apatite have already been obtained.

Opening No. 11 is situated about fifty yards W. N. W. from No. 10. It is thirty feet in length by five in width, and for a distance of eighteen feet has been sunk to the depth of twelve feet. A beautiful vein, or more probably bed of green apatite has been exposed, striking east and west, and averaging at least two feet in thickness. From this opening sixty tons of *first quality* have already been obtained. The walls of this promising deposit are regular and well defined.

2 feet bed of green apatite.

Opening No. 12 is about five yards to the eastward of No. 11, and is undoubtedly on the same bed or vein. It is a *stripping*, fifteen feet in length by three feet in width, and exposes a bed or vein of green apatite, averaging at least twelve inches in width. The strike is still east and west, and the underlie 75 degrees to the northward. This is among the most promising of the deposits of apatite in this concession. Upwards of six tons of good mineral had already been obtained from it.

Promising deposit.

Opening No. 13 is twenty yards north of No. 10. It is a trench fifteen feet in length, on a six-inch vein of green apatite, with which is associated a good deal of black mica. The direction of the trench and vein, or more probably bed, is N. 80° W., almost parallel to that at Nos. 11 and 12.

Opening No. 14 includes two small pits, seven feet apart, on a vein striking N. 75° W., situated about fifteen yards N. E. of opening No. 13. The solid rock has not yet been reached, but the soil abounds in pyroxene and mica, and upwards of half a ton of apatite has been obtained.

Opening No. 15 is twenty yards to the north of No. 14. It is a trench thirty feet in length by four feet in width, and is twenty-five feet deep. This cutting exposes one of the finest veins or beds of apatite I have yet met with. It averages at the bottom of the cutting at least three feet of solid green phosphate, and I was informed by the miners, that for the greater part of the twenty-five feet it had measured fully four feet. The strike of this bed or vein is N.W. and S.E. It is in a vertical position, with well defined walls composed of a hard, dark, granitic rock. Upwards of 120 tons of good apatite had been obtained from this deposit prior to the date of my visit.

Three-feet bed of green apatite.

Opening No. 16 is a small opening forty yards N.E. of No. 15. It is six feet by four, and only three feet deep, and is made on a number of irregular pockets of green apatite, of but little importance. The accompanying rock is a garnetiferous gneiss, striking N. 82° W.

Opening No. 17 is situated about 100 feet to the south-eastward of the windlass over opening No. 15. It is a trench of about fifty feet in length

by four feet in width, and bears N. 75° W. A fine vein of green apatite with mica is here exposed along the full length of the opening, having an average thickness of three feet. The adjacent rock is of a granitic character. Five tons of *first quality* phosphate of lime had been obtained prior to the date of my examination. Three-feet vein of apatite.

Opening No. 18 is twenty yards N.N.W. of No. 17. It is twenty feet in length, five feet in breadth, and about six feet deep. Here another fine vein of green apatite is exposed, striking to the north-westward and perhaps averaging two feet in thickness. I observed a considerable quantity of a light-coloured mica in large crystals toward the ends of the cutting, which may yet become of value. The deepest part of this opening is thirty yards from the centre line of the lot. Altogether, there has been obtained from it twenty-five tons of good apatite. Two-feet vein. Large mica crystals.

Opening No. 19 is fifteen yards N.W. of No. 18. It is a pit, ten feet long, four feet wide, and about six feet deep, sunk upon a vein of green apatite which varies from six to eighteen inches in thickness. The apatite is accompanied by large quantities of whitish mica in fair sized crystals. This appears to be a continuation of the vein or bed at opening No. 18, as it is exactly on its strike, and both openings show the same association of apatite and white or light-coloured mica. Upwards of five tons of apatite had been obtained from this small opening. The country rock is still of the same granitic character. Continuation of vein at No. 18.

Opening No. 20 is 100 yards north of the windlass over opening No 15. It is fifteen feet in length by four in width, and is only four feet deep. The apatite occurs in the form of a series of pockets traversing a very micaceous and pyroxenic rock in a north-westerly direction, or as near as could be made out N. 60° W. I was informed that ten tons of phosphate of lime had been obtained.

Opening No. 21 is about twenty yards W.N.W. of No. 20. It is a *stripping* about six feet in length, and exposes a vein of green apatite, eighteen inches in width, for a distance of five feet.

Opening No. 22 is thirty-five feet in length, from three to five feet in width, and from four to seven feet deep. It exposes a vein of green apatite, varying in thickness from two to three feet, and striking in an east and west direction. The adjacent rock here is syenitic. Over twenty tons of *first-class* apatite had been obtained prior to my arrival. I regret to say the exact position of this opening was accidentally omitted in my notes, but it is within a few yards of No. 21. Two to three-feet vein of green apatite.

Opening No. 23 is about twenty yards nearer to the windlass on No. 15. It is a trench thirty feet in length by six in width, and is six feet deep. A vein of green apatite, eighteen inches in thickness, has been exposed, striking N. 75° E., with an underlie of 80 degrees in a northerly direction. About forty tons of a fine green apatite had been obtained. Vein eighteen inches thick.

Opening No. 24 is a small surface excavation near the east end of 23, exposing a vein of apatite about twelve inches in thickness.

Opening No. 25 is twenty-five yards W.N.W. of No. 22, on a vein of green apatite fifteen inches in width. It occurs in a very soft and crumbling micaceous rock.

Opening No. 26 is on the side of a hill about the centre of the half lot, and seventy yards W.N.W. of No. 25. It exposes a vein of apatite having a thickness of eighteen inches, but the mineral is much intermixed with carbonate of lime.

Opening No. 27 is twenty yards north of the last; it is on a vein or bed of compact green apatite, which strikes N.W. and S.E., and has been uncovered for a distance of twenty feet. Upwards of five tons had been obtained from the surface. The walls are of hard, granitic rock.

Opening No. 28 is thirty yards east of No. 27. It is ten feet long and three feet wide, and exposes a vein of apatite eighteen inches thick, striking N.W. and S.E., and in similar granitic rock.

Opening No. 29 is thirty yards east of No. 28, and exposes a vein of apatite ten inches in thickness, striking N. 10° W. Openings Nos. 27, 28 and 29, are on parallel and equidistant veins.

Opening No. 30 is thirty yards N.W. of No. 29, and is six feet long by three wide. It is on an irregular mass of green phosphate.

THE MCKINLEY LOT.—On this lot, number three in the eighth concession, there are upwards of twenty-four openings, the most extensive of which are those worked by Messrs. Ritchie & Jackson of Belfast, Ireland, up to the close of the year 1871. These last have already been referred to in my report on the phosphate of lime deposits of North Burgess in the Report of Progress 1871-72, page 125, but further investigations have put me in possession of additional important facts relating to this grand deposit of apatite. Commencing with Messrs. Ritchie & Jackson's workings, the following are the most important of the openings.

Messrs. Ritchie and Jackson's Mine.

Opening No. 1 is the main shaft. It is situated almost immediately to the south of the road through the lot, and about two-thirds of the way across from the side line of lot two. (See accompanying plan of North Burgess.) The shaft is about six feet square, well timbered with cedar and ash, and has been sunk vertically to a depth of thirty feet through a very quartzose granitic gneiss. It is on a bed or vein of greenish phosphate of lime, which has been found to vary in thickness from eighteen inches to as much as seven feet. At the time of my visit there was no means of descending this shaft, as the ropes and buckets had been removed from the windlass, and no work had been in progress for some time. At the depth of thirty feet, the vein, which up to this point had been nearly vertical, pitches to the northward

60°, and on being followed in this direction was observed to gradually lessen in dip, until, at twelve feet further down, it became nearly horizontal. Twenty feet S. 35° E. from the shaft, a man-hole three feet square and timbered with hemlock, has been sunk for the purpose of ventilation to a depth of twenty-seven feet to the vein. At a distance of sixty feet S. 55° E. from the shaft, another hole three feet square has been sunk to a depth of fifteen feet, through a quartzose gneiss on to apparently the same vein, and five tons of phosphate were obtained. Forty yards S. 55° E. from the shaft, a trench has been cut to a depth of ten feet through the same quartzose gneiss. This cutting runs to the north-eastward for about fifty feet and into a swamp. It was made for the purpose of tapping the vein and draining the workings, but in this the miners were not successful as the vein was not struck. An adit level has likewise been driven through a very hard gneiss for a distance of thirty yards, on a bearing S. 80° E., from the man-hole, beyond which it continues as a trench twenty feet in depth for a hundred feet farther, bearing N. 65° E. On this last bearing a small vein of green apatite was exposed. Beyond this point the trench turns off sharply to S. 70° E. for fifty feet, terminating in the swamp. In this distance a second small vein was exposed. From these two veins on the course of this trench, over eighty tons of apatite were obtained. The level did not prove very successful, as it only drained the shaft to a depth of twenty-two feet, below which the water had to be pumped out. A vein of apatite, probably a shoot from the main deposit, has also been followed for thirty feet in a northerly direction from the main shaft. When the shaft was twenty feet deep, an adit level six feet in height by three or four feet in breadth was driven through a black micaceous rock in a north-easterly direction for a distance of sixty feet. A level was then commenced from the side of a hill and driven forty feet towards the adit, when all work was stopped, leaving about forty yards of rock between the ends. Altogether the main vein or bed has been worked for a distance of eighty-five feet, and to an average depth of twenty-five feet below the surface. As previously stated it reached a maximum width of seven feet, and, varied from this to eighteen inches. The average width may be estimated at three feet. The apatite now shows at the bottom of the shaft and cuttings as pockets in a dark and very quartzose gneiss rock, and it is worthy of note that the phosphate here is not much associated with mica. As nearly as I could ascertain, upwards of 450 tons of *first class* apatite have already been obtained from this vein.

Adit level.

Apatite bed seven feet thick.

Opening No. 2 is forty yards from the side line of lot four, and 120 yards south of the road. It is a trench forty yards in length in an east and west direction, three to four feet wide, and from six to fifteen feet deep, which has been made by blasting entirely through a hard greyish

granitic gneiss. The vein is roughly parallel to that at No. 1, and is nearly the full width of the trench. I regret to have to state that work has here also been suspended. About fifty tons of good apatite were obtained.

Sulphate of baryta.

Close to the side line of lot four, I observed a large mass of solid barytes that must have contained close upon fifteen cubic feet, lying alongside of a cavity in the soil from which it probably was raised. I could see no indications of a vein in the adjacent rock, which is a garnetiferous gneiss, but this loose mass is in all likelihood connected with the vein of sulphate of baryta, that is known to exist upon the fourth lot in the ninth and adjacent concession. The barytes is opaque white, lamellar, and contains no impurity, except small grains of copper pyrites.

Opening No. 3 is on the west side of the hill into which No. 2 cuts from the eastward. It is a trench, twelve feet in length by twelve in depth through a feldspathic granite, and bears S. 70° E. following an irregular vein of apatite. This vein has been traced from opening No. 2, in all a distance of fifteen yards. About ten tons of phosphate have been obtained. The strike of the gneiss, 200 yards to the south of the main shaft of opening No. 1, is N. 60° E.

Opening No. 4 is about 150 yards from the side line of lot two, and about forty yards below the road. It is a cutting ten feet in width and twelve feet in depth into the north side of a hill. The apatite, which is granular, occurs in a series of pockets in gneiss.

Opening No. 5 is about thirty-five yards N. 70° E. from the main shaft, and is fifteen feet in length, eight feet wide, and averages about five feet in depth. The apatite occurs in pockets in a loose feldspathic rock, and is accompanied by a great deal of greyish mica in large crystals. Ten tons of phosphate have been obtained.

Opening No. 6 is two-thirds of the way across this lot from the side line of lot two, and about 75 yards from the shore of Otty Lake. It is merely an uncovering or stripping of the rock, exposing several irregular pockets of apatite, from which about two tons have been obtained.

Opening No. 7 is about seventy yards from the side line of lot four, in line with opening No. 6, and sixty yards from it. It is an opening ten feet long, five feet wide and three feet deep, on some irregular bunches of green apatite, which are embedded in a very micaceous rock. Two tons were obtained.

Opening No. 8 is about seventy yards from the line of lot four, and thirty yards above the road.* It is forty yards in length, in a bearing N. 20° E., four feet in width, and from six to eight feet deep. Here a

* The road referred to in this and all of the foregoing descriptions of openings is correctly laid down on the accompanying plan of North Burgess.

beautiful vein of red and greenish apatite has been exposed, running through a quartzose and pyroxenic gneiss, and having a width of ten inches. From this vein, about thirty tons have been obtained. Towards the north-eastern end of the opening, a vein of iron pyrites, averaging nine inches in thickness, accompanies the apatite for a distance of ten feet. This association of iron pyrites is not of uncommon occurrence amongst the apatite veins of North Burgess, and I have in several instances observed both of these minerals intimately intermingled in a granular form. Vein of iron pyrites.

Opening No. 9 is about ten yards N.N.E. of No. 8. It is triangular in form, twelve feet in depth, and is apparently on a junction of two veins, namely, that from opening No. 8, and another vein which bears N. 75° E. The rock between the converging veins is twelve feet in width, and the side walls of the veins are clearly defined for a distance of fifteen feet. Upwards of forty tons of apatite have been obtained from this opening.

Opening No. 10 is thirty yards S. 75° W. of No. 9. It is a trench fifteen yards in length, five feet wide, and ten feet deep, on a vein of apatite striking N. 75° E. At or near the surface this vein was over two feet in width, but in the bottom of the cutting it now only measures about four inches. The surrounding rock is a red feldspathic granite. Fifty tons of good phosphate have been extracted and shipped.

Opening No. 11 is about seventeen yards N. 80° E. of No. 9. It is six feet by eight, and about six feet deep, and upon a pocket of green apatite occurring in a feldspathic granite. About four tons of phosphate have been obtained.

Opening No. 12 is forty yards east of No. 11, and about forty yards N.N.W. of the main shaft No. 1. It is a cutting fifty feet in length, five feet in width, and five feet in depth, on a vein of apatite bearing in the same direction, and from this superficial working twenty-five tons of phosphate have been obtained.

Opening No. 13 is just seven yards north of No. 12. It is an open cutting sixty yards in length, five feet wide, and of an average depth of fifteen feet, on a vein of phosphate striking to the N.W. At one point a pit has been sunk to the depth of thirty-five feet. The country rock is very quartzose and of a granitic character. Towards the north-west end of the vein there is a good deal of mica in crystals. The average width of the vein is about two feet, and from it there has been obtained 110 tons of *first class* apatite. Mica crystals.

Opening No. 14 is about fifty yards N.N.E. of the main shaft (No. 1,) and twenty yards E.S.E. of opening No. 13. It is ten feet long, six feet wide, and eight feet deep, on a pocket of apatite occurring in granite, from which four tons have been taken.

Opening No. 15, close by the last, is twelve feet long, four feet wide, and five feet deep, on a series of irregular pockets of green apatite, running N. 60° W., from which about five tons of phosphate were extracted.

Opening No. 16 is fifty yards N.W. of No. 13, and is eight feet in length by four in width, and four feet deep. It has been made on a series of pockets containing apatite and mica, which appear to bear in a N.W. direction through a feldspathic rock, containing but little quartz. About five tons of apatite have been obtained. Close by there is a good exposure of garnetiferous gneiss striking east and west.

Opening No. 17 is about 100 yards in a northerly direction from 16, near the centre of the lot, and about two-thirds of the distance from the front of the same lot. It is twenty yards in length in an east and west direction, four yards wide, and about five feet deep. A branch cutting, three yards wide and six feet deep, runs off S. 20° E. for a distance of eighteen feet on another vein of apatite. The mineral is associated with carbonate of lime in pockets, from which nearly 100 tons of good phosphate of lime have been obtained. The immediately adjoining rock is a hard granitoid gneiss.

Apatite with calcite in pockets.

Opening No. 18 is ten yards N. 70° E. from No. 17, and is six feet long, four feet broad, and five feet deep. It is in a vein of green apatite that is said to have averaged seven inches in thickness, bearing N. 55° W., and dipping at an angle of 70° to the north-eastward. About two tons of apatite have been obtained.

Opening No. 19 is ten yards to the eastward of No. 17, and is very similar to it. It is twelve feet long, six feet wide, and six feet deep, on pockets of apatite in a matrix of carbonate of lime. About five tons of apatite have been obtained from it. The surrounding rock is garnetiferous gneiss, striking east and west.

Garnetiferous gneiss.

Opening No. 20 is about 110 yards west of No. 17, and has a windlass erected over it. It is a trench twenty feet long, four feet wide, and from five to fourteen feet deep, on the course of a vein of apatite averaging twelve inches in thickness. The surface rock is here very soft and micaceous. Towards the rear of this lot there occurs a mass of pellucid white quartz which has been quarried to a small extent. From its purity it would, perhaps, be of value for glass manufacture. The strike of the gneiss on this part of the lot is N. 70° E., and the dip appears to be south-easterly.

Opening No. 21 is in the side of a hillock to the south-east of Andrew's lake, about three-eighths of the way across the lot, and 300 yards from the concession line. It is merely a stripping, exposing a narrow and irregular vein of apatite, averaging perhaps four inches, and much mixed with carbonate of lime. The rock is a micaceous gneiss.

Opening No. 22 is twelve yards N. E. of No. 21. It is an excavation twelve feet wide, and has been cut for eight feet into the side of a hill. There is not the slightest appearance of a vein, yet I was informed that over ten tons of green apatite had been extracted; the mineral is said to have contained a good deal of black mica. The rock here is a garnetiferous gneiss, striking east and west, with southerly dip $<60°$.

Opening No. 23 is also in the side of a hill and 15 yards to the N. E. of No. 22. It is a stripping, twenty feet in length, and three feet deep, on a vein of green apatite, striking N. 25° W., and about seven inches in width. In another place, close by, the apatite exposed measured two feet across, but I could not decide whether this was a vein or not. A little over one ton of apatite was obtained. The country rock is still garnetiferous gneiss.

Opening No. 24 is about seventy yards from the side line of lot two, and about three furlongs from the point of the lot. It is a trench fifteen feet long, four feet wide, and three feet deep, bearing N. 80° W. Two tons of apatite have been extracted.

Lot 4, eighth concession.

Lot 4.—On the fourth lot of the eighth concession, the property of Edward Flaherty, there are only four openings of importance. They are as follows:

Opening No. 1 is on the upper side of the road through the lot, and about two-thirds of the way across from the side line of lot three. It is twelve feet long, five feet broad, and about five feet deep, and was sunk on a vein of phosphate of lime striking N. W. and S. E. This vein is now completely exhausted, about three tons of apatite were obtained from it.

Opening No. 2 is eighty yards from the side line of lot five, and forty yards above the road. It is twenty-five feet square, and sixteen or seventeen feet deep, on what at one time appeared to be an irregular mass of apatite, from which I was informed 300 tons had been obtained. The deposit is now quite exhausted.

Opening No. 3 is twelve yards, W. N. W. of No. 2. It is seven feet long, three feet wide, and six feet in depth, and is on a mass of loosely granular apatite, from which three tons were obtained. There is no appearance of a vein in either this or the last locality.

Opening No. 4 is forty yards from the side line of the lot, and between it and pit No. 3. It is ten feet in length, four feet wide and seven feet deep. Four tons of apatite were obtained from another irregular mass. The apatite deposits on this lot, as represented by these four workings, may be said to be exhausted. The openings were chiefly made by Edward and Andrew Watts, during the year 1871, when they held the mineral right of the property.

Lot 5, eighth concession. 38 openings.

Lot 5.—Lot five of the eighth concession, belonging to the Hon. R. Matheson of Perth, has a great many shows of apatite. I examined in all some thirty-eight openings and strippings.

Opening No. 1 is seventy yards from the side line of lot four, and twenty chains from the front of the lot. It is a slight stripping, exposing a vein of green apatite and mica, about twelve inches wide, striking N. N. W. through a feldspathic rock.

Opening No. 2 is twenty yards west of No. 1; and is seven feet by four, and three feet deep. Apatite shows in the bottom for a width of two feet, apparently striking N. W. and S. E. with micaceous side walls. The deposit, however, was not sufficiently stripped to enable me to examine it satisfactorily. Over five tons of apatite have been obtained.

Opening No. 3 is eighteen yards west of No. 2, and is a stripping, exposing apatite for twelve inches.

Opening No. 4 is about the centre of the lot, and twenty chains from the concession line. It is also a stripping or superficial opening, exposing a vein of apatite mixed with mica, striking N. 60° W., and measuring two feet in width. The rock is a micaceous gneiss.

Opening No. 5 is fifty yards N. 30° W. from 4, and is a stripping exposing a vein of apatite eighteen inches in width for a distance of seven feet. It runs about N. W. through a granitioid gneiss.

Opening No. 6 is twenty yards N. 15° E. from No. 5. It is a stripping showing a vein of apatite running N. 15° W., and varying from four to fifteen inches. In this direction, at the north-west end of the opening, a vein fifteen inches wide diverges to the westward. Two tons of apatite have been extracted at the distance of twenty feet N. 15° W. The soil has also been removed, shewing a continuation of the same vein.

Opening No 7, is fifty yards below the road through the lot, (see map) and about twenty-five yards N. 55° W. of No. 6. It is a stripping showing a vein of apatite striking N. W. and S. E. and varying from five to twenty-four inches in width. The country rock is a red feldspathic granitoid gneiss.

Opening No. 8 is seventy yards below the road. It consists of three strippings, showing a vein of green apatite for a length of ten yards, bearing N. 20° W. through red feldspathic rock, and averaging about twelve inches in thickness.

Opening No. 9 is twenty feet south of No. 8. It is a stripping, five feet in length by four in width, exposing a vein of green apatite two feet wide, running N. 75° W. Another vein, six inches wide, branches off to the southward. One ton of apatite has been obtained. The country rock here is feldspathic and very micaceous.

Opening No. 10 is twenty feet to the west of 9, and exposes a vein of green apatite eighteen inches in width, bearing N. 25° W., from which four tons have been taken.

Opening No. 11 is on the road, and about two-thirds of the way across the lot from the side line of lot four. It shows a vein of phosphate of lime nine inches in width, bearing N. 70° E.

Opening No. 12 is also on the same road, and about forty yards from the side line of lot six. It exposes a vein of apatite one foot in width, striking N. 55° E., through a pyroxenic rock.

Opening No. 13 is immediately below the road, and one-quarter of the way across the lot from the side line of lot four. It exposes an inch vein of apatite, striking N. 15° W. This is probably the same vein as that at opening No. 7, and were a line drawn S. 15° E., it would pass through the latter opening at a distance of fifty yards.

Opening No. 14 is on the upper side of the road, ten yards from Kenyon's gate, and close to the side line of lot four. It is a trench fifty feet in length, five to six feet in width, and twelve to fifteen feet deep, on a bed of a light pink carbonate of lime, striking N.W. and S.E., and containing a large amount of green apatite. At the south-eastern extremity of the trench the apatite shows as a solid vein, two feet in width, between walls of pyroxenic gneiss. Twenty feet from this point the trench turns to the westward, following a bend in the vein. The trench in this part is five feet wide and seven feet deep, and the apatite has a width of three feet towards the western extremity. It is here more or less accompanied by crystals of mica. From this working upwards of 150 tons of good marketable phosphate of lime have been obtained.

Vein of apatite two to three feet thick.

Opening No. 15 is twenty yards S.W. of No. 14, and is fifteen feet in length, three feet in width, and three feet deep. It exposes a layer of green apatite, from twelve to eighteen inches in width, bearing N. 70° W., and accompanied by white crystalline quartz. About six tons of apatite have been obtained. The gneiss is very micaceous.

Opening No. 16 is ten yards N.E. of No. 15, and is ten feet long, four feet wide, and five feet deep, sunk on a layer of carbonate of lime, containing pockets of green apatite. About five tons were obtained.

Opening No. 17 is seven yards from the side line of lot four and eight yards N.W. of No. 14. It is eight feet in length, five feet wide, and four feet deep, and exposes a six-inch vein of green apatite, bearing N. 75° W. Another small opening, five yards further on this bearing, strikes the vein again, where it is of the same width. The adjacent rock appears to be a dark grey quartzite. Five tons of apatite were obtained.

Opening No. 18 is forty yards from the side line of lot four, and in line with No. 17. It is a superficial opening, showing a layer of green apatite twelve inches in width, bearing N. 35° W.

Opening No. 19 is seven yards west of No. 18, and is nine feet long, four feet wide, and about four feet deep, exposing a layer of red apatite seven inches in thickness, bearing N. 60° W. Three tons have been obtained.

Opening No. 20 is close by No. 19, and is eighteen feet long, four feet wide, and six feet deep. It is sunk upon a vein of green apatite, which

bears N. 75° W., through a very micaceous gneiss. The apatite has a width of two feet at the western extremity of this cutting. Twelve tons have been extracted.

Opening No. 21 is one hundred yards S. 60° W. of Nos. 19 and 20. It is a stripping five feet in length and three feet in width, on a layer of green apatite twelve inches in thickness, bearing N. 80° W.

Opening No. 22 is one hundred and twenty yards S. 60° W. of No. 21, and is also a stripping, twelve feet long and four feet wide. A layer of green apatite runs the whole length of the opening, and about three tons of apatite had been extracted previous to my arrival.

Opening No. 23 is forty yards west of No. 22. It is a stripping on a vein of green apatite, varying from fifteen to thirty inches in thickness.

Opening No. 24 is seventy-five yards N. 80° W. of No. 21, and is twelve feet long, four feet wide, and three feet deep. It exposes a vein or bed of apatite about twelve inches in width, bearing in an east and west direction, in a pyroxenic gneiss.

Opening No. 25 is about 200 yards above the road, and is merely an uncovering for six feet, upon a pocket of green apatite, varying from fifteen to twenty-four inches in width.

Opening No. 26 is fifteen yards west of No. 25, and exposes a layer of apatite, twelve inches in width, in a very quartzose gneiss rock. The apatite is here accompanied by black mica.

Opening No. 27 is twenty yards east of No. 25, and shows a vein of apatite about fifteen inches wide, bearing N. 25° W. The surrounding rock is garnetiferous gneiss, striking N. 75° W.

Opening No. 28 is twenty-five yards N. W. of No. 27, and is ten feet in length, four feet in width, and three feet deep. Here a vein of green apatite bears N. and S., varying in width from one to three feet. Over three tons of good phosphate of lime have been obtained from this stripping.

Opening No. 29 is twenty yards north of No. 28, and consists of two small strippings on a vein of green apatite, striking N. 10° E., and varying from one to two feet in width.

Opening No. 30 is ten yards N. 10° E. of No. 29, and would appear to be on a continuation of the same vein. It is a mere stripping exposing a vein of green apatite, eighteen inches in width. The rock is very quartzose and contains mica and pyroxene.

Opening No. 31 is fifteen yards N. N. W. of No. 30. It is a stripping, showing a vein of mica and apatite, striking N. 20° W.

Opening No. 32 is twenty yards N. E. of No. 31. It is a superficial opening, shewing a vein of green apatite, twelve inches in width, striking to the N. W. through a garnetiferous gneiss.

Opening No. 33 is twenty-five yards E. N. E. of No. 32, and exposes a vein of green apatite, four inches in width, striking N. 60° W.

Opening No. 34 is about twenty-five yards south of No. 33, and is on a vein of apatite, eighteen inches in width, striking north-westward.

Opening No. 35 is about 600 yards from the rear end of the lot, and one-third way across the lot from the side line of lot four. It is on a vein of apatite, twelve inches in width, striking W. N. W.

Opening No. 36 is fifteen yards N. W. of No. 35, and exposes a vein or bed of apatite, averaging fifteen inches in width, and bearing N. 55° W. This deposit is probably a continuation of that at opening No. 34, being nearly on the same bearing, and much resembling it in general character.

Opening No. 37 is ten yards to the north of No. 36, and shows a vein of green apatite, nine inches in width, bearing N. 60° W. The adjacent gneiss is very quartzose.

Opening No. 38 is seven yards to the south-eastward of No. 37, and is probably on the same vein. It shows six inches of green apatite in a vein also striking N. 60° W. Gneiss very quartzose, in parts almost a quartzite.

The greater number of the foregoing openings or strippings on this lot have been made more with a view to the future sale of the lot, than for the purpose of developing the deposits of apatite. They, however, have afforded an excellent opportunity of studying the different forms in which the mineral occurs.

LOT 6.—On lot six in the eighth concession there are ten openings, but the greater number of these are of but little importance. They are as follows: **Lot 6 eighth concession.**

Opening No. 1 is near the centre of the lot, and is nine feet in length, six feet wide, and six feet deep. Apatite shows towards the northern end of this opening, in an irregular vein, apparently bearing N. and S., in a feldspathic gneiss.

Opening No. 2 is about fifty yards in a south-westerly direction from No. 1, and is made in the side of a hill. The apatite here occurred in pockets in gneiss.

Opening No. 3 is about fifty yards to the west of No. 1, and is of a more promising description. It is a cutting running in an east and west direction for twenty-five yards, six feet wide, and from six to twenty feet in depth, and is sunk on a bed of carbonate of lime, which contains a large amount of apatite in the form of crystals. The adjacent rock is a bluish-grey gneiss. About twenty tons of apatite in crystals had been extracted by the last lessee, and I was informed it had been worked profitably by the previous lessee.

Opening No. 4 is twenty-five yards in a westerly direction from No. 3. It is about twenty feet in length, six feet wide, and twelve feet deep, and

shews apatite in veins striking nearly N. and S., and varying in thickness from six inches to three feet. Another small opening to the eastward shews apatite in crystals mixed with carbonate of lime.

Opening No. 5 is ten yards to the N.E. of No. 4. It is a circular opening six feet in diameter, and ten feet deep. The apatite was intimately mixed with dark coloured mica.

Opening No. 6 is eight yards north of No. 4, and is twelve feet long, six feet wide, and ten feet deep. It shows a nine-inch vein of green apatite and mica, striking in an east and west direction.

Opening No. 7 is immediately to the northward of No. 6, and is ten feet by five, and eight feet deep. No phosphate of lime was seen, as the opening was choked with rubbish.

Opening No. 8 is immediately northward of No. 7, and is a circular pit about five feet in diameter and six feet deep. It is now choked up with rubbish.

Opening No. 9 is close by the last, and is a trench twenty-five feet in length, six feet wide, and about twelve feet deep, on a vein of green apatite striking N. 60° E. The apatite here is unaccompanied by mica.

Opening No. 10 is close upon twenty chains north of No. 9, and about 150 yards from the side line of lot five. It is ten feet in length, six feet wide, and six feet deep, and has been sunk upon a shallow basin-like form of apatite, from which two tons have been taken. The rock is a hard bluish-grey gneiss.

LOT 7.—The last lot examined was the seventh lot of the eighth concession, on which there are nine openings. They are as follows:

Opening No. 1 is a circular pit, ten feet in diameter, and about fifteen feet deep, situated five yards from the shore of Otty Lake. It has been sunk in a loose feldspathic rock, in which mica occurs in irregular pockets.

Mica. I believe this opening was first made in search of mica, and I was informed that a considerable amount of it had been obtained. Some of the crystals of mica yielded cut plates measuring eight inches by ten, and were of a

Copper ore. clear white colour. Indications of copper ore were observed in this pit, and also in the adjacent rock.

Opening No. 2 is a few yards S.S.W. of No. 1, and on the shore of Otty Lake. It is a cutting down the side of a hill, exposing a vein of green apatite, varying from a few inches to three feet in width, and striking N. 80° W. Eight tons of apatite have been obtained.

Opening No. 3 is a few yards N.N.E. of No. 1, and is a cutting down the bank of the lake. The apatite occurred in the form of crystals in a crumbling feldspathic rock.

Opening No. 4 is a few yards N.N.E. of No. 3, and is on the edge of Otty Lake. This opening runs eighteen feet into the side or face of a hill, and I believe was made in search of white mica. There is some scattered apatite in the adjoining rocks.

Opening No. 5 is about fifteen yards N. 30° W. of No. 4. It is a trench, twenty-six yards in length, running N. 70° W. From this working a large amount of mica, of marketable sizes, was at one time obtained. At the depth of twelve feet a layer of apatite, eight or nine inches in width, was struck and exhausted. I could not learn what amount of apatite had been obtained.

Opening No. 6 is about 180 yards N.N.E. of No. 5, and is twelve feet long, four feet wide, and fifteen feet deep. It exposes a vein of red apatite of irregular width, running N. and S. through a highly feldspathic rock.

Opening No. 7 is immediately to the east of No. 6, and is an irregular excavation, measuring about twelve feet in diameter, and eight feet in depth. It shows some scattered patches or pockets of green apatite in a rock largely composed of feldspar. Upwards of thirty tons of apatite have been obtained from this and the last opening.

Opening No. 8 is twenty yards to the north-westward of No. 6. It is seven feet by five, and six feet deep, on a pocket of reddish apatite from which half a ton was obtained.

Opening No. 9 is fifteen yards north of No. 6, and is seven feet by six, and about six feet in depth. It was originally sunk in search of mica, but this was of a very dark colour. In the bottom of the present opening there is a vein of green apatite measuring four inches in thickness.

As will be seen from the foregoing notes, the deposits of apatite on this lot are irregular and of but little importance, and I believe that they are near the limit of the "phosphate-bearing zone."

PLUMBAGO AND APATITE DEPOSITS, OTTAWA COUNTY.

Plumbago and apatite, Ottawa county.

Towards the latter end of last October, and on the completion of my general investigations, I visited the townships of Buckingham, Templeton and Portland to the northward of Ottawa City, and devoted the few closing days of the season to an examination of certain deposits of plumbago and apatite the occurrence of which had previously been reported to me. This examination was rather more hurried than I should have desired, as the deposits appear to be of considerable economic importance.

Lower Laurentian rocks.

The rock masses met with through Buckingham and the adjoining townships consist chiefly of several varieties of gneiss, crystalline limestone, pyroxenite, mica schist and quartzite, with here and there protrusions of red granite or syenite. These rocks are undoubtedly Lower Laurentian, and further, it is probable they are on the same horizon as the rocks of Burgess, Bedford and Loughboro', in the counties of Frontenac and Lanark. In Buckingham, the workable deposits of graphite occur almost invariably in proximity to one or more of the bands of crystalline limestone. The graphite is found in three distinct forms: (1) as disseminated scales or plates in the limestones, gneisses, pyroxenites, quartzites, and even in some of the

iron ores, (as at Hull); (2) as lenticular or disconnected masses embedded in the limestones, or at the junction of these and the adjoining gneisses and pyroxenites; and (3) in the form of true fissure veins cutting the enclosing strata.

The first form is that most commonly met with, and it is in the limestone that the graphite is most abundantly disseminated, oftentimes to such an extent as to constitute deposits of great economic value. The second form, namely, that of embedded masses, is of common occurrence, and in a number of localities in Buckingham, Lochaber, and Grenville, such deposits have been met with and worked to a small extent. The third, or last form, that of fissure veins, is not of so common occurrence, and does not appear to be of as great importance as the bedded deposits, although many such veins exist and have been wrought to some extent in the townships already named. In these the graphite is very brilliant, often lamellar and of great purity. Dr. T. Sterry Hunt, in referring to this form of deposit in the report of the Geological Survey, 1863–1866, now out of print, says: "It will probably be found that the highly crystalline lamellar graphite belongs in all cases to true veins where a slow process of deposit has allowed it to assume that mode of aggregation and that purity which characterizes other minerals thus deposited." Pure as is this vein-form of graphite, my experience shows that it is to the bedded deposits of this mineral that we must look for our chief supplies, and in this opinion I follow Sir Wm. E. Logan, who, in the report already cited, says: "The veins of this mineral hitherto found in the rocks of this country, although affording a very pure material, appear to be too limited and too irregular to be exclusively relied on for mining purposes, which should rather be directed to making available the large quantities of graphite which, as we have seen, as disseminated in certain beds." Such beds are particularly well developed in the portion of Buckingham examined, as well as in the contiguous township of Lochaber.

Graphite veins.

Observations of Dr. Hunt and Sir W. E. Logan.

On lots twenty-five in the fourth and twenty-four in the fifth concession of Buckingham the mineral occurs in the form of irregular veins and dis, connected lenticular masses in graphitic limestone, which strikes in a north-east and south-west direction, with a steep dip to the south eastward. Through both of these lots this limestone is in considerable volume, and the graphite is largely disseminated through it in scales and crystalline plates. The veins, as already mentioned, are very irregular and of limited extent, varying from one to about six inches in thickness. On the east half of the twenty-fourth lot an opening or pit has been sunk in a black graphitic limestone, to a depth of sixteen feet, which in all proba bility is the same as that referred to by Sir W. E. Logan, (Report 1863 1866), as having been worked by Mr. Labouglie. Sir William says, "The ore-bearing portion appears at this spot to run along the face of a

Labouglie's mings.

low abrupt cliff, and to dip S. 80° E. with a precipitous slope. The stratification, however, is obscure, and it is not easy to determine the thickness of the mass, which, however, cannot be less than six feet. A considerable amount of rock raised from the pit lies at the surface, perhaps 100 tons, one-half of which might be fit for dressing." Other openings have also been made on this lot by Mr. Labouglie, but none of them are extensive.

Openings have also been made on the twenty-fifth lot of the fourth concession, and, on the strike of the beds, on the twenty-fourth lot in the fifth concession. Besides those which have been worked there are also numerous other reticulating veins of graphite of minor importance. Judging from the great number of exposures of the mineral through both of these lots, it seems probable that, by a systematic course of prospecting, some rich and workable deposits of graphite will be brought to light.

In the fifth concession, on lot twenty-seven, and towards its north-western corner, a large opening was made some few years ago on two or three parallel beds of graphite, by West & Co. At the time of my visit, owing to heavy fall rains, this opening was almost entirely filled with water, which circumstance prevented me from making such an examination as I could have wished. The pit is about ten feet square, and is sunk to a depth of ten feet. In it, three beds of graphite could be distinguished, striking about N.E., and S.W., with steep dip to the south-eastward. Two of these varied in thickness from six inches to two feet, while the third, shewing a thickness of one foot, held the mineral in a disseminated form, in a mixture of carbonate of lime, sand and clay. I was informed that upwards of twenty barrels of pure graphite had been extracted and sent away from this opening by West & Co., and there still remains a considerable quantity of material fit for dressing around the mouth of the excavation. Openings by West & Co.

In the sixth concession, on lots fifteen and sixteen (Crosby Newton's), graphite is also found to some extent, but little has been done in mining it. The mineral occurs disseminated in a band which is both calcareous and quartzose, in the form of brilliant crystalline plates or scales. In places the rock is so rich in graphite that it might perhaps be worked with profit in connection with some of the more valuable deposits, were a mill erected in the vicinity. The strike of the rocks on these lots is rather obscure, but from their general characteristics they would appear to be a continuation of those seen to the south-eastward, on the nineteenth lot of the fifth concession, where a considerable amount of work has been done and some very important deposits uncovered. (See Geological Report, 1866, page 23). Crosby Newton's lot.

The south half of the twenty-third lot in the sixth concession was next examined, and also in connection with it the twenty-second of the

same concession. Through both of these lots graphite was observed in considerable quantity, but no systematic mining has been attempted. Such small openings as there are appear to have been made at random; yet, even these indicate the existence of a great amount of the mineral. A ridge or hill, rising to the height of over eighty feet, runs in an east and west direction through the lots. It is composed of a rust-coloured rock, largely made up of feldspar and quartz, through which is disseminated an abundance of graphite in scales and often plates of considerable size. Irregular veins and pockets are also of frequent occurrence all along the course of the ridge. This lot is particularly well situated, being in close proximity to the water power between Twin and Donaldson's Lakes.

The Castle property.

Lot twenty-three in the fifth concession of Buckingham is also a good graphite location. It was worked a few years ago to some extent, when it was known as the Castle property. These two lots are about six miles from the village of Buckingham, and only five miles, in a straight line, from the Ottawa River. They form a location, which may perhaps be considered as one of the most promising in the township.

Pennock's lot, southern half.

The west half of the fourth lot in the seventh concession is also reported as rich in graphite; but this we did not examine. On the south half of lot twenty-one, in the same concession, a rather large vein of very pure graphite has been opened upon. The opening is about ten feet by five and four feet deep; the vein varies in width from one to one and a-half feet, and runs in a W.S.W. direction. This is the southern half of Pennock's lot, which, up to this season, has been worked with considerable promise. The specimens obtained from this location were of great purity, and compared favourably with some graphite now in Montreal from Ceylon. From this lot the mineral was traced upwards of three miles to the south-eastward in a series of parallel bed-deposits, through which there also occur transverse veins.

The south half of lot twenty-seven in the seventh concession of Buckingham is immediately to the northward of lot twenty-eight in the sixth concession, another of the lots included in the Castle property on which some work was done a few years ago. On the first mentioned lot several ridges of rock with disseminated graphite were noted, running in an east and west direction, and I was shewn one or two small openings under the roots of some trees on the edge of a pond or beaver meadow, from which several specimens of rock rich in graphite were obtained; but as yet no extensive openings have been made here.

Lot 28, sixth concession.

Lot twenty-eight in the sixth concession, which immediately adjoins the north-west corner of the last enumerated lot, was examined some years ago by Sir W. E. Logan, and mention is made of it in the Geological Report for 1863-1866.

On the twenty-seventh lot in the sixth concession of Buckingham, the graphite mine known as Messrs. Pugh & Wert's is situated. This mine was somewhat extensively worked a few years ago, and yielded a very large amount of graphite. The shaft is about forty feet deep, on a bed averaging perhaps three feet thick, and striking N.E. and S.W., along the course of which an open cutting has been made, to a distance of over sixty feet. **Lot 27, sixth concession. Pugh & Wert's mine.**

Lots four and five of the ninth concession have also been more or less prospected, and have afforded promising indications of the mineral. They are some distance from the circle of graphite lots which surround Donaldson's Lake, but it is extremely probable that they will be found to be on a continuation of the same, or a series of similar and parallel beds, the general course of both being north-east and south-west. On the fourth lot very little work has been done, but a band of rock with thickly disseminated graphite, bearing S. 40° W., was observed, and traced on this course to the front of the lot. On lot five, an opening was made in a rust-coloured band of rock, in which, besides much graphite in a disseminated form, there occur also several embedded masses, and irregular veins of the same mineral. The strike of this band was, as nearly as could be made out, S. 60° W., the dip being to the westward at a steep angle. The opening was made in a vein of earthy graphite varying from two to five inches in width, and running along the south face of the ridge. A second opening, on the side of the hill uncovered a bed of amorphous graphite, of from two to two and a-half feet in width; for a distance of fifty feet; it is associated with a dark graphitic limestone. There are several other openings on this ridge shewing graphite, and some of the beds could be traced into the tenth concession. Lot five is about four and a-half miles from the village of Buckingham, and is not far off the projected line of the Northern Colonization Railroad. **Lots 4 and 5, ninth concession.**

On lots three and four, in the tenth concession, a continuation of the bedded deposits just noted was met with. No openings of any consequence, however, had been made, and consequently the examination was merely superficial. Altogether, I am more favourably impressed with the indications on the lots in the vicinity of Donaldson's Lake. **Lots 3 and 4, tenth concession.**

In the township of Lochaber another lot was examined, but I did not succeed in procuring the correct number of the lot and concession. It was said to be the north half of the twenty-sixth lot in the third concession, but I have since had reason to consider this incorrect. On this lot several important beds of disseminated graphite were observed, running parallel to the stratification of the adjacent rock, one of which was from three to five feet in thickness, and was uncovered to the extent of one chain. This would seem to be a deposit of some importance.

Apatite in Buckingham and Portland townships.

Apatite or Phosphate of Lime.—The discovery of apparently workable deposits of phosphate of lime in this section of country is of comparatively recent date, although a number of persons whom I met at Buckingham village had long known of the existence of this valuable mineral in parts of Buckingham and Portland townships. Amongst these was Captain A. McNaughton, a gentleman who had not only himself collected specimens from many parts of the country contiguous to Buckingham, but who has also had them brought to him by settlers from remote parts of the Gatineau and Rivière du Lièvre. Besides Captain McNaughton's collections, I had the opportunity of examining one or two others in the possession of store keepers in Buckingham village, all of which threw much light not only upon the economic minerals existing in the back country, but also upon the character of the rock formation. Amongst these specimens graphite largely predominated, both in the massive and disseminated forms; next came the ores of iron, both magnetite and hematite; and lastly, and less numerous, were undoubted specimens of apatite or phosphate of lime, both in the form of crystals, and as irregular grains, disseminated in a rock composed largely of granular pyroxene or coccolite. From the information gleaned from persons in Buckingham, it was evident that the Rivière du Lièvre would afford me the best opportunity of reaching the most important of the deposits of apatite; I therefore ascended the river from the village to the foot of the "High Falls" in the township of Portland, in all a distance of about twenty-five miles. For nearly the whole of this distance the river runs with great rapidity between high clayey banks, and little or no rock approaches the shores until reaching a rapid known as 'Little Rapids," situated about the eighth lot of the first concession of Portland; but high ranges of rocky hills were observed to flank the stream on either side, at a distance varying from an eighth to half a mile. At the "Little Rapids" the general strike of the rocks is to the north-eastward. In character they strongly reminded me of the pyroxenic varieties of rock found associated with the apatite in North Burgess and Loughboro' townships. Immediately at the foot of the rapids, and on the left shore, there is a beautiful, although rather irregular, deposit of green, crystalline apatite, which had been worked for a short time prior to my visit. The miners, however, had thrown out a great deal of useless stuff, most of which was the green, granular pyroxenic rock of the variety known as coccolite. Seeing this rock carefully piled aside as if for shipment, and remembering the numerous instances which had come under my notice in which similar rock had been mistaken for phosphate of lime, I made enquiry, and, to my surprise, was informed that this material had been analysed in the United States, and found to contain upwards of 75 per cent. of phosphate of lime. This analysis, however, I am convinced, was

Pyroxene mistaken for apatite.

of the pure green form of apatite which is associated with the pyroxenic rock, as specimens of the latter sent by me to the Geological Survey office, and analysed by Dr. Harrington, contained no phosphate.*

The Garret mine

This location is known as the "Garret mine," and a crushing mill is shortly to be erected on it. Immediately across the river, and on the east half of the seventh lot in the first concession of Portland, phosphate of lime again occurs in a similar pyroxenic rock, with which is also associated a great deal of white orthoclase gneiss. A few blasts had been put in on the east face of a high bluff, and these had exposed several small, irregular veins of pure green apatite; but the mineral will probably yet be found in greater quantity on other portions of the lot. Phosphate of lime is also found on the property of A. Walsh, Esq., of Ottawa, on the twenty-seventh lot in the twelfth concession of Buckingham, but in a very irregular form. On this lot some six openings were observed, but they were all filled with water at the date of my visit. There are several other localities in Portland township in which phosphate of lime has recently been found, but until the country becomes better cleared and settled, the extent of such deposits cannot be satisfactorily determined. All through these townships, however, there are rocks of similar character to those in North Burgess and Loughboro'; such as crystalline limestones, granular pyroxenic and white quartzo-orthoclase rocks, with red and whitish orthoclase gneisses, in all of which both apatite and mica occur to a greater or less extent.

Other apatite localities in Portland township.

Lots 18 and 19, twelfth concession.

The only other locality at present to be noted, and probably a very promising one, is on the eighteenth and nineteenth lots of the twelfth concession of Buckingham. These lots are situated on the east side of the Rivière du Lièvre, and the deposits of apatite occur in a high ridge of rock, within a few rods of the water. These deposits, though but little uncovered, are undoubtedly extensive. The mineral is translucent and of a green colour, and is apparently very pure, being free from both mica and pyroxene. At the base of a bluff I observed some very large detached masses of pure phosphate of lime, which must have tumbled down from the face of the hill. I should strongly recommend a stripping of this side of the bluff, which could be easily accomplished by two or three men, with picks, and with but little expenditure. As there are no rapids between this point and Buckingham village, shipment could be effected with great facility.

BARYTES.

Sulphate of Baryta.

A beautiful vein of this mineral occurs on the west half of the seventh lot in the tenth concession of the township of Hull. It varies in width from two to three and a half feet, and was traced for upwards of 100 yards in a N.N.W. direction. The adjacent rock is a highly crystal-

*I have since learned that this barren rock has not been shipped from the mine.

line, white limestone (Laurentian), striking N. 22°30′ E., and dipping to the south-eastward at a steep angle. The barytes is of an opaque white colour, and is associated with sea-green fluor-spar, which occurs chiefly towards the outer edges of the vein. This fluor-spar is hardly in sufficient quantity to detract from the value of the barytes; besides, when ground it forms a powder of almost as white a colour as the latter, and is only deficient in the requisite weight. A similar sea-green fluor-spar occurs abundantly with some of the iron ore at the Haycock iron mines, where it might almost be mistaken for apatite. No galena has yet been found in connection with the barytes on this lot. In the Geological Report, 1863–1866, page 20, Sir W. E. Logan refers to a vein of barytes from four to six inches in width as being found on the south half of this same lot, which is probably a continuation of the larger vein. Specimens from the latter are at present being tested in Montreal. I should further mention that the distance from this property to the River Gatineau is only four miles. The mineral right is at present held by the Hon. Peter Mitchell and F. P. French of Ottawa.

I have the honor to be,

Sir,

Your most obedient servant,

HENRY G VENNOR.

Montreal, May, 1874.

REPORT

ON THE EXPLORATION AND SURVEY OF THE

SPRINGHILL COAL FIELD, CUMBERLAND COUNTY, NOVA SCOTIA,

BY

MR. SCOTT BARLOW.

ADDRESSED TO

ALFRED R. C. SELWYN, F.R.S., F.G.S.,

DIRECTOR OF THE GEOLOGICAL SURVEY.

SIR,—I beg to lay before you a statement of the progress made in the exploration of the Springhill coal-field, County of Cumberland, Nova Scotia, during the summers of 1872 and '73.

A synopsis of the results of my work in that field during a part of the summer of 1870 and the summer of 1871, which I had the honour to lay before you in the spring of 1872, was embodied in your Summary Report for 1871-72; and you were then pleased to direct me, to continue the exploration, devoting my attention principally to the productive part of the field; to trace out and prove the outcrop of the 11 feet, or "Black seam" on one of the Springhill Mining Company's areas, where its con tinuity was doubtful, and to put down boreholes, or small pits, at any points I deemed necessary, so as to arrive at a knowledge of the structure of the field; and also, as I could afford time, to prosecute the general exploration and survey of the whole field. These instructions I have endeavoured to carry out, having, during the season of 1872, put down numerous boreholes, 940 feet in all, proving 25 chains of the outcrop, besides surveying (with prismatic compass and chain) 53 miles of rivers, roads, streams, &c., and collecting rock specimens and fossils. Work of 1870 and 1871. Work of 1872.

During the season of 1873, as you are aware, it was deemed necessary to prove the measures to the south-west of the Springhill Mining Company's west slope, nothing being known of them except in a pit some 20 feet deep on the General Mining Association's area, distant about 51 chains, and on the west bank of the Coal Mine Brook, near Miller's Hotel, where a seam of coal 13 feet 6 inches in thickness had Work of 1873.

been found; and in another pit on the "Hibbard area" (now belonging to the Springhill and Parrsboro' Mining and Railway Company) where a seam was also found, said to be of about the same thickness. Borings were therefore made across the strike of the strata from the said pit on the General Mining Association's area, and have proved the existence of four underlying seams, the section being nearly the same as at the Springhill Mining Company's west slope—allowing for the difference of the respective angles of inclination, viz. 23° on the 13 feet 6 in. seam, and 33° at the slope.

Borings.

Outcrop of the 11 feet or Black seam.

From where the 11 feet or "Black seam" was struck on this section, its outcrop was traced, with the assistance of Mr. John Anderson (who was employed by the Springhill and Parrsboro' Mining and Railway Company), and its identity with the seam found in the "Hibbard pit" was thus proved. During the season, 400 feet of boring was accomplished, and 16 trial pits were sunk on the outcrops of the various seams to prove their thickness; the average depth of these pits was 15 feet; altogether 240 feet. Several of the pits being in wet places were very difficult to sink.

Survey of the Springhill Mining Company's area.

A survey of the new slopes and buildings on the Springhill Mining Company's area, together with several miles of roads, was made by theodolite and chain.

The Styles mine.

I also visited the Styles mine, where Mr. Jas. S. Hickman, of Amherst, has put down a small slope to the east of the old Styles pit. (See page 158.)

Complicated character of the structure.

As the structure of the field is of a very complicated character, and important faults are known to exist in it, further work is needed before it can be described with any degree of accuracy; this is chiefly in consequence of the few natural exposures of the strata, most of which are only to be seen in the beds of the rivers and brooks during the dry season; besides this, the limited time hitherto at my command for careful examination, renders me unable to construct continuous sections. Most of the exposures have been visited, and I hope during the coming season to be able to compile many of the sections with comparative accuracy. In the mean time a description of the work done, and approximate sections of the coal seams, are given in the present report.

Acknowledgment of assistance.

I must not conclude these introductory remarks without expressing my obligations to the following gentlemen for assistance in various ways, during the past four years: to Mr. Gilbert Seaman, Minudie; Mr. George Hibbard, Minudie; Mr. Jas. S. Hickman of Amherst; Mr. John Livesey, Londonderry Mines; Mr. A. J. Hill, C.E., Sydney, C.B.; Mr. Byers, M.E.; Mr. E. N. Sharp of St. John, N.B.; Mr. John Cooper, Springhill, and Mr. Wm. Hall, Manager of the Springhill Mining Company's works. I have also to acknowledge assistance and information received at various

times during the progress of the work from other gentlemen whose names I cannot now recall.

MAP.

From measurements made by myself, and from the plans of sections 2 and 4 of the Intercolonial Railway, I have been enabled to construct a map on a scale of 20 chains to an inch, which when finished will extend from River Philip on the east, to the Joggins shore on the west, and from the valley of the Upper Maccan River on the south, to the town of Amherst on the north; thus including all of what is called the "Cumberland Coal Field." The scale of this map being considered too large for present publication, a reduction of a portion of it to 80 chains to an inch (or one inch to a mile), embracing an area of 280 square miles, is presented with this report. This map shews the southern outcrop of the coal seams at Springhill, and also what is supposed to be the northern outcrop of the same seams from the Maccan Colliery eastward to the Styles mine. In connection with this survey it may be stated that the Maccan River, from the mill at the junction of the Etter and Maccan roads to Athol and the lower part of East Brook and Rattling Brook, was surveyed (with prismatic compass and chain) by Mr. W. McOuat during the season of 1873, as also the upper parts of Little Forks River, Baird Brook and Pugsley's Brook, together with Styles Brook, and the details of that part of the Amherst and Truro post road between Logan's Mill and Black River. Map of the "Cumberland coal field."

The road from Southampton to Athol was taken from a survey made in 1872, for the Department of Mines, Halifax, N.S. by Prof. J. E. Oram, of King's College, Windsor.

The Springhill Branch Railway, and Springhill and Parrsboro' Railway, were laid down from plans kindly furnished me by Mr. W. D. Barclay, C. E., the engineer in charge.

The boundaries of the coal leases, licenses to work, and licenses to search (marked on the map in dotted lines), are taken from plans issued on the authority of the Department of Mines, Halifax, Nova Scotia, and are only approximately correct. The areas marked M.E. Co., refer to leases and licenses to work, and search, taken out by the Mineral Exploration and Mining Company of Nova Scotia.

SPRINGHILL COAL SEAMS.

The following is a description of the coal seams proved at Springhill. Commencing at the Springhill Mining Company's west slope, on the 11 feet or "Black seam," and going north, the dip being N. 60° W. $<$ 33°, and Description of seams at Springhill.

NOTE.—The bearings are all given in reference to the true meridian. The variation is 21° 45′ west.

the run of the crop N. 19° 30′ E., the seam for a distance of thirty-two and a-half chains was proved by numerous trial pits; here the course of the outcrop is N. 13° W.; on account of the depth of the drift, at this point 40 feet, and supposed to increase, no pits or boreholes were put down for a distance of 12 chains. At this distance a borehole was made, and the drift found to be 45 feet in thickness; the coal was reached at 10 feet more, and bored into 7 feet—62 feet in all. From this point, continuing on the same bearing 5½ chains, the seam was proved by 3 boreholes, the thickness of the coal being 10 feet, including 6 inches of clay, and the angle of inclination 38°: this is at the Springhill Mining Company's east slope. Continuing 6 chains further, the seam was tested by 2 more boreholes, made under my direction, and one trial pit by Mr. Anderson, and in these, at 7 feet from the surface of the ground, 10 feet of coal was found, with 9 inches of clay in the centre. The following is an approximate section, in descending order, of the seams which have been proved by small pits sunk on the crop of each seam, the inclination of the beds being 38°:—

Sections.

		Ft.	in.
	Blue argillaceous shale		
6 feet seam......	*Coal*	3	0
	Clay	0	6
	Coal	2	6
	Fire-clay. and concealed measures, supposed to be thin beds of grey sandstone, with blue argillaceous shale	128	0
	Grey argillaceous shale with ironstone balls	2	0
2 ft. 4 in. seam.—	*Coal*	2	4
	Fire-clay, and concealed measures, supposed to be thin beds of grey sandstone, with blue and grey argillaceous shale	185	0
"Black seam"	*Coal*	5	0
	Clay	0	9
	Coal	4	3
	Fire-clay and concealed measures, supposed to be thin beds of grey sandstone, with blue and grey argillaceous shale	70	0
3 inch cropping.—	*Coal*	0	3
	Fire-clay, and concealed measures, supposed to be thin beds of grey sandstone with blue and grey argillaceous shale	110	0
2 ft. 6 in. seam.—	*Coal*	2	6
	Fire-clay		
	Total,	516	1

Continuing from this pit on the same bearing, N. 13° W., at 2¼ chains further, the thickness of the seam was proved by boring at a depth of 18 feet from the surface of the ground, as follows:—

		Ft.	in.
	Blue argillaceous shale.		
11 feet or "Black seam."	*Coal*	5	4
	Clay	1	0
	Coal	4	7
	Fire clay		
		10	11

And three chains further a second borehole gave :—

	Ft.	in.
Blue argillaceous shale.		
Coal	3	6
Clay	1	3
Coal	3	3
Fire clay		
	8	0

A third borehole 3 chains further :—

Blue argillaceous shale.		
Coal	4	9
Fire clay		

A fourth borehole $2\frac{1}{4}$ chains further :—

Blue argillaceous shale.		
Coal	6	9
Fire clay		

And 2 chains further, or 19 chains from the Springhill Mining Company's east slope, a pit was sunk which gave the following section, the strike being N. 10° 45′ W. and angle of inclination 17° :—

	Ft.	in.
Surface (drift)	11	2
Grey sandstone	2	0
Blue argillaceous shale	0	5
Hard, grey sandstone, with false bedding	2	9
Blue argillaceous shale	4	8
Coal	0	9
Slate	0	$0\frac{1}{2}$
Coal	2	3
Coal and fire clay	0	$2\frac{1}{2}$
Hard, grey, argillaceous understone, full of stigmaria		
Total,	24	3

From this pit for a further distance of $20\frac{1}{2}$ chains, still on the bearing N. 13° W., till another pit put down by Mr. Anderson is reached, no coal has been found, the reason probably being that there is a down-throw fault to the north, which carries the outcrops of the underlying seams to the east. The ground being swampy, and the drift increasing to 33 feet in depth, I was deterred on account of expense from boring here. But at the point mentioned, and across the swamp, Mr. Anderson sunk a pit, and by boring in the bottom of it, at a depth of fourteen and a half feet proved a seam of the following thickness, the dip of the overlying strata being S. 61° W. < 44° and the strike N. 29° W.: Seam proved by M. Anderson.

	Ft.	in.
Blue argillaceous shale and thin bands of hard, grey sandstone	10	0
Coal	6	4
Fire-clay		
	16	4

4¾ chains further, on a bearing N. 29° W., the coal was again reached in a pit, and found of the same thickness, (6 feet 4 inches). Here the bearing was changed to N. 10° 30′ W. for a distance of 3½ chains, and the seam found to hold the same thickness. In 1½ chains more it becomes mixed with clay and strikes N. 66° W., dipping S. 24° W. At a distance of 8 chains further on the same bearing, a seam 6 feet thick, measured vertically, was again reached by boring; and about 5 chains further on, a pit showed at twelve feet from the surface a seam 2 feet 10 inches thick, dipping S. 12° W. < 44°.

From this point for 5 chains, on a bearing N. 75° W., the seam averages 1 foot 8 inches in thickness. At 1½ chains still further on a pit shows the following section, the dip of the beds being S. 22° W. < 50°:—

	Ft.	in.
Surface, red clay and gravel	10	0
Clay with boulders, some of them limestone	18	0
Blue argillaceous shale	4	0
Coal	2	0
Fire-clay		
	13	0

6 inch seam.

At 13 chains from this last pit, on a bearing N. 76° 30′ W., a 6 inch seam of coal was reached by a pit. It is underlaid by two others, as shown in the following approximate section, in which the measures are given in descending order:—

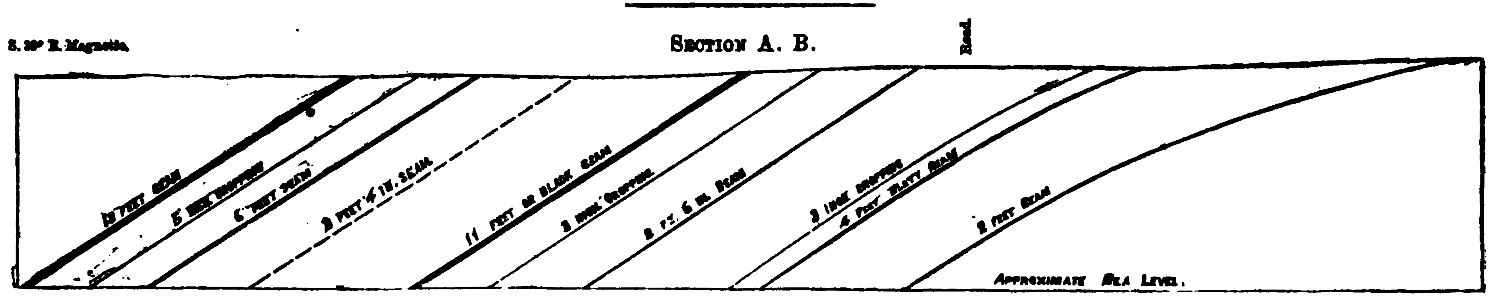
	Ft.	in.
Hard, grey sandstone	1	6
Coal	0	6
Fire-clay and concealed measures, probably thin beds of hard, grey sandstone, and blue and grey argillaceous shales	75	0
Hard, grey arenaceous shale, containing two erect fossil tree stools, 20 inches in diameter and about 18 inches high, resting on the coal	2	6
Coal, shaly	0	6
Fire-clay and concealed measures, probably thin beds of grey sandstone, and grey and blue argillaceous shale	78	0
Blue argillaceous shale with iron-stone balls	3	8
Coal	1	10
Measures concealed, probably thin beds of grey sandstone, coal, and blue and grey argillaceous shales, about	1,400	0
Concretionary limestone (fossiliferous); 5 feet exposed with 6 inches of brown clay in the middle.	5	0
Total,	1,568	6

Pitt near Springhill Branch Railway

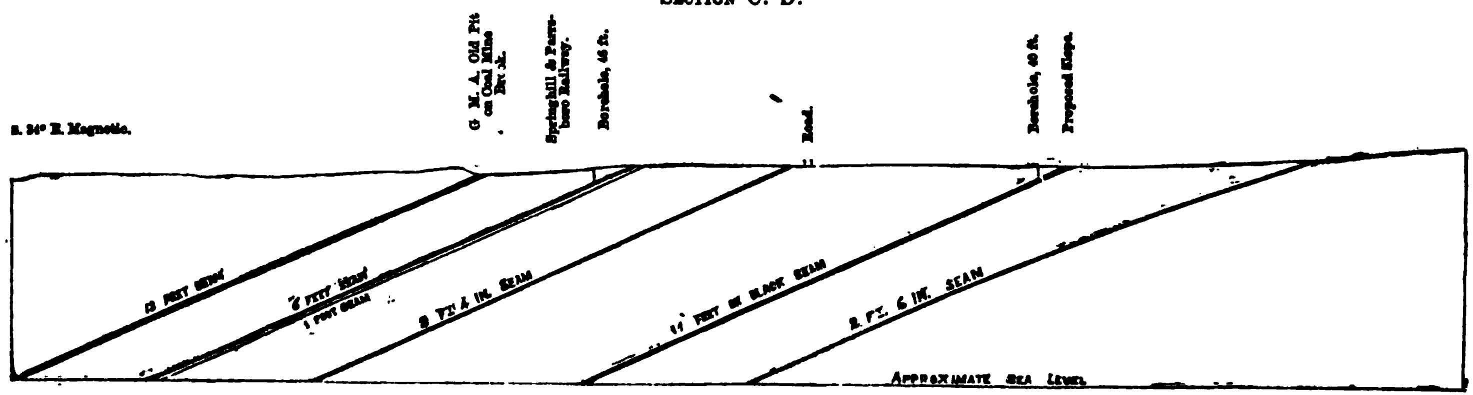
Proceeding on a bearing N. 8° 30′ W. for 38 chains, the Springhill Branch Railway is reached, on the west side of which a small pit shows the following section :—

SECTIONS OF COAL MEASURES AT SPRING HILL.

SECTION A. B.



SECTION C. D.



Scale 400 feet to an inch.

	Ft.	in.
Surface, clay and gravel	7	0
Grey argillaceous shale	0	9
Hard, grey band of rusty weathering sandstone	1	8
Soft grey argillaceous shale	0	3
Coal (with a little dirt)	1	4
Fire-clay	2	0
Shale with iron-stone balls		
	23	0

Beyond this pit to the northward no coal has been found.

I shall now endeavour to describe the outcrops of the seams to the south-west of the Springhill Mining Company's west slope. Starting on a bearing S. 27½° W. from the slope, at a distance of 51 chains, a borehole was made, in which the 11 feet or "Black seam" was found, the angle of inclination being 23°, or ten degrees less than at the slope. The underlying 2 feet 6 inch seam, and the three overlying seams, were also proved here, as shown in the accompanying section, C. D. At this point the Springhill and Parrsboro' Mining and Railway Company propose putting down a slope. They had previously sunk a small pit, but the ground being very wet, it was thought best to wait till this spring before going on with the work. Before I left Springhill in the beginning of December last, they had put up two wooden buildings for blacksmith and carpenter shops, and were hauling the timber for the slopes. Outcrops south-west of Springhill Mining Co's west slope.

For a distance of 12 chains from this point the seam was proved by Mr. Anderson by 4 other boreholes, along a line bearing S. 34° W. Thence the crop sweeps round to the south, in which direction it was proved for 5 chains by boring, and in a small pit sunk a year ago the dip was ascertained to be N. 81° W. $<$ 17°. From this point for 5½ chains, to the "Hibbard pit," where the coal is disturbed and dips more to the south of west, the seam was proved by means of 4 boreholes. The following is a section of the measures here, the angle of inclination varying from 24° to 34°:—

	Ft.	in.
Surface	11	0
Grey argillaceous shale with ironstone balls	2	0
Coal with several partings of slate	8	3
Slate	0	1
Coal	0	11
Hard dark brown slate	0	9
Coal	1	3
Hard, dark blue understone		
	24	3

There is evidence of either a fault or an undulation here, as in boring at 1 chain from this pit to the dip, the seam was found at the same depth Fault or undulation.

6 feet seam traced by Mr. Anderson.

from the surface. 14½ chains from this pit on a bearing S. 68° W. Mr. Anderson sunk a small pit on a seam of coal, which I believe to be the 6 feet seam which overlies the Black seam. The following is a section of the measures as seen in the pit, the dip being due west < 12°:

	Ft.	in.
Surface	11	6
Grey freestone	4	0
Blue argillaceous shale	1	2
Coal, with an inch of blue argillaceous shale in the middle.	4	6
Fire-clay	20	2
	41	4

Mr. Anderson traced this seam by boreholes for 4½ chains on a bearing S. 7° E.; he then tried, for the 13 feet 6 in. seam, but did not find it, probably because of his not boring far enough to the dip. This work was done during the winter.

4 feet seam.

Fault.

At a distance of 2 chains from the "Hibbard pit" bearing S. 24° W. Mr. Anderson put down another pit, and found a seam of good coal, 4 feet in thickness, with hard, dark blue understone, diping S. 24° W. < 27°; and following on the strike S. 66° E. for 5½ chains he got about the same thickness of coal in a borehole. As there is evidence of a fault with a downthrow to the south of about 60 yards, which brings the crop of the seam to the east, 116 yards on the surface, this may be the continuation of the 11 feet or "Black seam." The run of the fault as near as I can judge is N. 62° W. On the rising ground distant from the "Hibbard Pit" 9 chains and 30 links, on a bearing S. 70° E., Mr. Anderson bored into a thick seam of coal, which I believe to be the continuation of the 11 feet or "Black seam" to the south of the fault; and although it was late in the season, the snow being on the ground, and much water to contend with, I succeeded in putting down a pit to the depth of 31½ feet, proving 10 feet 11 inches of coal at right angles to the plane of the beds; but was not able to sink through it, as the men stopped working on account of the cold. The dip is S. 57° W. < 38°; strike S. 83° E. The following is a section of the measures:—

11 feet on black seam.

	Ft.	in.
Surface boulders and running gravel	12	0
Hard grey sandstone (lower 2 feet calcareous)	5	0
Brown argillaceous shale with ironstone balls	1	10
Grey argillaceous shale	1	6
Fire-clay	0	2
Coal, good	2	0
Black slate	0	1
Coal, with three ½ inch streaks of black slate and numerous films of carbonate of lime	8	9
Hard blue slate	0	1
Coal	0	0
	31	

This is the furthest point to the south-west, that the coal has been traced.

Approximate section in descending order, a little to the North of the Springhill Mining Company's west slope; marked A.B. on map. Section.

		Ft.	in.
	Blue argillaceous shale.		
Top, or "13 ft. 6 in." seam, according to the measurement of Mr. Anderson in a pit sunk on the east bank of Mill's Brook.	*Coal*	5	9
	Clay	0	7
	Coal	1	3
	Clay	2	0
	Coal	4	6
	Fire-clay, and concealed measures, probably thin beds of grey sandstone with blue and grey argillaceous shale	70	0
	Coal		5
	Fire-clay, and concealed measures, probably thin beds of grey sandstone with blue argillaceous shale	65	0
	Coal	2	2½
	Blue argillaceous shale and fire-clay	8	4
	Coal	3	2½
	Fire-clay	3	0
2 ft. 4 in. seam, (not proved.)	Measures concealed, probably thin beds of grey sandstone with blue argillaceous shale, including a 2 ft. 4 in. seam of *Coal*	180	0
	Blue argillaceous shale with ironstone balls	2	0
11 feet or "Black seam"	*Coal*	2	0
	Slate	0	1½
	Coal	8	6½
	Fire-clay, and concealed measures, probably thin beds of grey sandstone with blue argillaceous shale	70	0
3 inch cropping	—*Coal*	0	3
	Fire-clay, and concealed measures, probably thin beds of grey sandstone with argillaceous shale	110	0
2 feet 6 inch seam	—*Coal*	2	6
	Fire-clay, and concealed measures, probably thin beds of grey sandstone with blue argillaceous shale	160	0
3 inch cropping	—*Coal*	0	3
	Fire-clay, and concealed measures, probably thin beds of grey sandstone with blue argillaceous shale	35	0
4 feet slaty seam	*Coal*, slaty with mineral charcoal on upper surface	4	0
	Fire-clay, and concealed measures, probably thin beds of grey sandstone with blue argillaceous shale	176	0
2 feet seam	—*Coal*	2	0
	Fire-clay.		
	Total,	918	11

The 2 feet 4 inch seam, which overlies the 11 feet or Black seam, was not proved in this section, but there is no doubt of its existence.

Approximate section of measures proved at General Mining Association's Old Pit, in descending order; marked C.D. on map.

		Ft.	in.
	Thin beds of grey sandstone and blue argillaceous shale.		
13 ft. 6 in. seam as given in Woodhouse and Jeffcock's Report on Cumberland Coal Field, 1865.	*Coal* (top coal, very good for roof,)......	1	6
	Dirt........	1	0
	Coal, good........	11	0
	Fire clay........	0	1
	Hard blue understone and concealed measures, supposed to be thin beds of grey sandstone with blue argillaceous shale........	105	0
6 feet seam........	*Coal*, slaty........	0	9
	Slate........	0	2½
	Coal, good........	1	4
	Coal, soft........	0	9
	Coal, good........	2	9
	Hard, blue understone, full of stigmaria; thin-bedded grey sandstone and blue argillaceous shale........	11	0
1 ft. coal and clay........	—*Coal* and clay........	1	0
	Hard fire-clay full of stigmaria, and concealed measures, probably thin beds of grey sandstone and blue argillaceous shale	120	0
2 ft. 4 in. seam........	—*Coal*........	2	5
	Hard blue understone, and concealed measures, probably thin beds of grey sandstone and blue argillaceous shale........	217	0
11 feet or "Black seam."	—*Coal*........	11	0
	Fire-clay, and concealed measures, probably thin beds of grey sandstone and blue argillaceous shale........	135	0
2 ft. 6 in. seam........	*Coal*........	1	6
	Clay and shale........	0	3
	Coal and shale........	0	10
	Fire-clay........	0	2
	Hard, greyish-blue understone.		
	Total,	624	6½

Approximate section, in descending order, of the measures proved to the rise of pit supposed to be on the 11 feet or "Black seam," 19 chains north of the Springhill Mining Company's east slope; dip 17°.

		Ft.	in.
	Surface.		
	Grey sandstone........	2	0
	Blue argillaceous shale........	0	5
	Hard, grey sandstone with false bedding...	2	9
	Blue argillaceous shale........	4	8
Perhaps representing the 11 feet or "Black seam."	*Coal*........	0	9
	Slate........	0	0½
	Coal........	2	3
	Coal and fire-clay........	0	2½
	Hard, grey understone (full of stigmaria), and concealed measures, probably thin beds of grey sandstone, and blue		

	argillaceous shale, with possibly one or two seams of coal	285	0
	Measures proved by small pits to be thin-bedded grey sandstone with blue argillaceous shale	100	0
3 inch coal cropping.—	*Coal*	0	3
(dip 26°)	Fire-clay, and measures proved by small pits to be thin-bedded grey sandstone with blue argillaceous shale	40	0
4 ft. slaty seam.—	*Coal*, slaty	4	0
	Fire-clay, and concealed measures, probably thin beds of grey sandstone with blue argillaceous shale	95	0
2 ft. 4 in. seam.—	*Coal*	2	4
(dip 26°)	Fire-clay, and concealed measures, probably thin beds of grey sandstone with blue argillaceous shale	35	0
1 ft. 2 in. seam.—	*Coal*	1	2
	Fire-clay		
	Total,	575	10

SOUTH SIDE OF SPRINGHILL.

On the south side of Springhill, and on the license to work of Mr. E. N. Sharp, seams of coal were said to have been found by an American company which carried on explorations in 1865, and, it is said, expended $20,000. Unfortunately the records of this work cannot now be obtained. Numerous pits, however, were sunk, the position of which I have fixed and recorded on the accompanying map.

Coal discovered by an American company.

In connection with this I have to add that Mr. John Hill, M.E., exploring on behalf of Mr. John Livesey, early last June put down a small pit, 12 chains to the S.E. of Mr. Joseph Herrit's house, and found a seam of coal, a little to the dip of the old pits sunk by the American company. In this pit, which was emptied of water during the season, I measured the following section, the dip being S. 39° 45′ E. < 18°:—

Explorations on behalf of Mr Livesey.

		Ft.	in.
Hill's Pit.	Surface	10	6
	Dark slate	1	2
	Coal	1	9
	Grey agillaceous shale	0	2
	Coal	2	6
	Hard pavement		
		16	1

About 2 feet of this coal is strong and good.

On a bearing S. 50° W. from this pit, and for a distance of 7 or 8 chains, coal was found in three or four boreholes, put down by Mr. Probert, a practical miner who was also employed by Mr. Livesey.

To the east of the pit, on a bearing N. 67½° E., for a distance of 23 chains, reaching the road at about half-way between Mr. Joseph Herrit's house and Mr. Henry Smith's, two seams were said to have been found by Mr. Probert, who thinks that the upper one is the same as at Hill's Pit; several boreholes were put down but not being furnished with the records, I can say nothing definite about them. Mr. Livesey has continued the boring in this locality during the past winter, and I hope to be able to get the records of the work during the coming summer, as it is being carried

on under the superintendence of Mr. Thos. Lloyd, a mining engineer from Wales, who appears to be doing the work in a systematic manner.

NORTHERN OUTCROP.

Blight area and area No. 70.

On the northern outcrop prospecting has been carried on in a small way for the last two seasons. On the Blight area, and also on area No. 70, coal has been found by boring and sinking small pits at distant intervals; but the records have not been carefully kept, nor the work systematically carried on, so that little can be said about it, except at one point 9 chains west of the Old Styles Pit, where a small slope, worked by a horse gin, had been put down for about 40 feet from the crop by Mr. Jas. S. Hickman, of Amherst, when I was there in December last. The coal is much disturbed and slickensided, and apparently contains a good deal of sulphur. The seam here is supposed to be the same as that at the Scotia, Chiegnecto, and St. George Collieries. The crop of an overlying seam with about 17 feet of strata intervening has been bored into; this the miner in charge asserts to be the thicker (or top) seam formerly worked at the Scotia Colliery.

The dip at the mouth of the slope put down by Mr. Hickman is S. 24° 45′ E. < 42°; but at the face of the coal the angle of inclination lessens to 35°. Thefollowing section was measured at the bottom of the slope:

	Ft.	in.
Dark brown argillaceous shale with a little *Coal*	0	1½
Coal, apparently good	2	0
Dark brown clay and slate	0	7
Coal	1	1
Fire-clay		

2 feet of apparently good coal.

2 feet of the coal is apparently good; samples of it have been handed to Dr. Harrington for analysis.

Slopes at Springhill.

Slopes, machinery, etc.

Two slopes have been commenced 50 chains apart. The west one has been driven about 420 feet, and the requisite pumping and winding machinery erected. The engine is a single 16-inch cylinder with a four feet 6-inch stroke, geared three to one, and driving a 9-feet drum. Engines of a heavier class and more permanent character are in course of erection at the East slope, where in future the principal out-put is expected to be made. The ventilation of the present workings is effected by a furnace 6 feet wide erected at the outcrop. Houses each of two tenements for the married workmen, and larger ones as boarding houses for the accommodation of the unmarried workmen, are being erected.

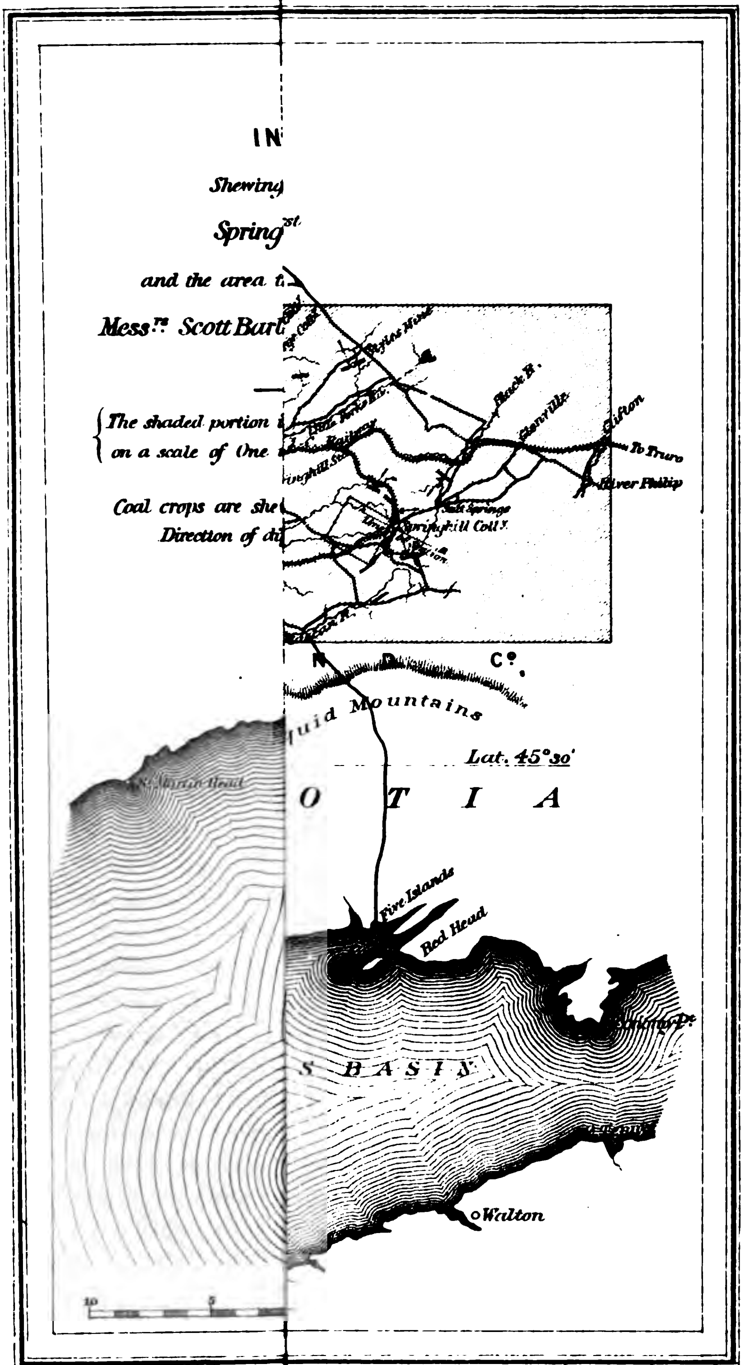
I have the honor to be,

Sir,

Your most obedient servant,

SCOTT BARLOW.

Montreal, May 1874.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REPORT

ON A PORTION OF THE

COAL FIELD OF CUMBERLAND COUNTY, NOVA SCOTIA,

BY

MR. WALTER McOUAT, B.A.

ADDRESSED TO

ALFRED R.C. SELWYN, Esq., F.R.S., F.G.S.,

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

SIR,—As directed by you, I was employed during the summer of 1873 in making a survey of a portion of the coal-field in the county of Cumberland, in Nova Scotia; and now I beg to submit the following statement of the work done. Instructions.

In this work I was assisted by Mr. Charles E. W. Dodwell, B.A., of Halifax, and Mr. Thomas McOuat, of Ottawa; and I have much pleasure in testifying to the intelligence and zeal with which both of these gentlemen applied themselves to their duties, which were usually of a very laborious character. Assistance

Commencing operations about the middle of June, some time was necessarily occupied in making a general reconnaissance of the country, in order to determine what particular portion it would be most advantageous to take up first. This done, the earlier portion of the summer, extending to about the end of July, was employed in making an examination of the country along the Maccan River, from the termination of Mr. Barlow's work at the Etter Road, down to Athol, and along the East Brook and its tributary, Rattling Brook, from the source of the latter to the junction of the East Brook with the Maccan at Southampton. Regions examined.

Mr. Scott Barlow, of the Geological Survey, having arrived on the ground before the end of July, to resume the work on which he had been engaged during several previous years, it was agreed between us that I should devote the remainder of the season to the district of country extending eastward along the north rim of the Cumberland trough, from the Chiegnecto and St. George Mines to the vicinity of the Post Road from Amherst to Truro. This locality was selected as a field of labour, with a view of determining a special point in the structure of the coal-field—a point to which you had called my attention before leaving Montreal. It was known that the Productive Coal measures, (Middle Coal formation of Dr. Dawson) with their seams of coal, which are exposed in the cliff at the South Joggins, extend inland with a nearly uniform east strike and south dip, as far as the Styles Mine near the above road, a distance of about seventeen miles. Beyond this, nothing, as far as I am aware, was known of their course, and an impression seems to have prevailed that they curved round to the south and west, and connected in some way with the coal measures on the south side of the basin. It was part of your instructions that I should endeavour to clear up this point, and I am glad to be able to report that I succeeded in doing so.

Special point determined.

Towards the end of the season a large amount of work was done on the east side of the Post Road already mentioned, extending from the Leicester Road on the north, to the Black River on the south. It may be stated here that the Post Road will be frequently mentioned in this report, and will be referred to simply as "the Post Road."

The Post Road.

The districts which I have sketched, as being the scene of our labours, are mostly wooded. Roads occur at wide intervals, bordered occasionally by clearings of greater or less extent, but there are seldom any rock exposures on these. The exposures, with few exceptions, are in the banks and beds of streams flowing usually through thick woods. The work of fixing the positions of the rocks observed, which it was necessary to do by making careful chain surveys of all the streams, though quite practicable, was unavoidably slow and laborious.

Rock exposures

We surveyed in this way the Little Forks River, from its source on the east side of the Post Road, to its junction with the Maccan at Athol, connecting here with our survey of the Maccan; also all the branches of the Little Forks except a few small ones on the south side. We also surveyed the branches of Pugsley's Brook, above the Chiegnecto and St. George Mines respectively, also Chase Lake Brook, a considerable stream which rises on the east side of the Post Road, near the source of the Little Forks, and flows southward to the Black River. In the earlier part of the season, as already stated, surveys were made of the Maccan, from the Etter Road down to Athol, also of Rattling Brook, and of the East Brook, from the Etter Road to its junction with the Maccan at

Streams surveyed.

Southampton. The whole distance chained, in surveying these streams, amounts to about 75 miles. The positions of rock exposures, and other objects to be noted, with reference to these measured lines, were ascertained by sets, measured by pacing. There were also some roads surveyed and lines measured through the woods, not on streams, to fix the positions of trial-pits sunk to prove the course of coal seams, and also in some cases to connect the surveys of streams with the more accurate measurements along the roads. A stake was planted at each station, bearing a number corresponding with that in our field-notes, so that any position can at any time be readily found without repeating the measurements. The number of stakes thus set was nearly two thousand.

Measurement of roads, &c.

These measurements have been all plotted on a scale of twenty chains to an inch, which is the scale adopted by Mr. Scott Barlow in laying down his surveys in the adjoining country.

A large collection of specimens was made, to illustrate the character of the rocks and the included fossils. A few of these, suitable for exhibition in the Museum, were brought to Montreal, but a much larger number, which were intended to be used, in the first instance, to facilitate the comparison of rocks from different localities, while the investigation was in progress, were left in Nova Scotia, that they might be available for next year. They will, however, be transported to Montreal, and deposited in the Museum of the Geological Survey as soon as my work in the field under consideration shall have terminated..

Collection of rocks and fossils.

The total area over which our work extended was about 80 square miles. The surveys made by us, and the facts observed, are, I think, sufficient to demonstrate the geological structure within this area, and, in a more general way, over a considerably larger area. There is, however, a considerable amount of work to be done, at many points, before this can be effected with the precision which would be desirable, and which would be attainable even without any more costly mode of investigation than a careful examination of all natural exposures. There are also some roads and small streams, of which surveys would require to be made before a complete topographical map of the area could be produced.

Total area examined.

It may be added that advantage was taken of occasional opportunities to make observations in portions of the Cumberland coal-field beyond the particular area which was more thoroughly worked up. Information was obtained in this way which was of use in giving a general idea of the whole, and which would be valuable should I be permitted to continue the examination of the coal-field so as to embrace the localities where these observations were made. Meanwhile, however, they are of too disconnected and incomplete a character to be incorporated with this report.

Roads surveyed by Mr. Barlow.

It should also be stated that some of the roads within the area to which this report relates had been previously surveyed by Mr. Barlow, and a tracing of his map, on which they are accurately laid down, was of great service to us.

Paucity of exposures, and thickness of drift.

On account of the paucity of exposures of the strata, more especially in the inland parts of the County of Cumberland, nearly the whole surface being covered with a varying thickness of drift, it is usually a work of considerable difficulty to make out the geological structure. The district examined by us is by no means exceptional in this respect. Notwithstanding the disadvantage, however, we succeeded in making out certain local characters which gave the means of determining the structure, at least approximately. We were able able to distinguish in the rocks associated with the Productive Coal measures five different members or groups of strata. Two of these are of such a character that they are much more frequently exposed than the others, and are readily recognized even when very slightly exposed. As there is good reason to believe that one of these two groups is immediately under, and the other immediately over the Productive Coal measures, the facts just stated are of very great importance.

Five groups of strata.

The lower of these two bands, or groups of strata, which will be first described, is a conglomerate, of which the thickness appears to be considerably over a thousand feet. It consists largely of pebbles of red syenite in which feldspar is the predominant constituent. There are other pebbles of greenish and grey quartzite, and a smaller number of porphyry, the whole more or less rounded. There are also fragments of a partially decomposed argillaceous substance, of a dull green colour, the colour being due, according to Dr. Harrington, to the presence of iron. A thin film of this substance usually coats the various pebbles and small particles of which the whole mass is made up, giving the conglomerate a characteristic greenish colour, though speckled on a freshly broken surface by the pebbles of red syenite. It is not a coarse conglomerate, the pebbles being seldom larger than a hen's egg, and often passes into a coarse sandstone.

Conglomerate.

Good exposure on Styles' Brook.

The conglomerate is best seen on a branch of the Little Forks called Styles' Brook. It is there exposed in the bed, and in the banks of the stream, for a distance of about ten chains below, and twelve above the bridge at the Gould Road. It occurs in massive beds often eight or ten feet thick. There are numerous concealed intervals, in many of which, no doubt, some softer rock occurs. In a few instances shale is seen, with flaggy argillaceous sandstones, usually of a reddish-brown colour. The thickness of the whole is about 1,000 feet, but in proceeding up the brook, after an interval in which nothing is seen except about fifty feet of red shale in a position that would underlie the conglomerate just described,

Shale and sandstone.

there is, at Weatherbee's Mill, another considerable exposure of conglomerate and coarse sandstone. Including this, the thickness of the whole would be about 1,500 feet. Weatherbee's Mill.

At a vertical distance of about 450 feet above the supposed summit of the conglomerate, there is an important seam of coal, an opening on which, on the west side of Styles' Brook, is known as the Styles mine, which has been already mentioned. This is thought to be the same seam which is worked at the St. George and Chiegnecto mines, the former four and a half, and the latter five and a half miles to the westward. I do not know that it can be regarded as certain that it is the same seam, but all the evidence seems to support this view. Explorations have recently been made along the line of strike, between the Styles and St. George mines, and coal reached by boring and sinking pits on the crop; and a line connecting all the points where coal has thus been found seems to correspond exactly with the strike of the rock in the vicinity. Important seam of coal. Explorations between the Styles and St. George mines.

The band of conglomerate, which may be conveniently designated the Styles' Brook conglomerate, was traced in a direction parallel with the above line of pits as far westward as the Chiegnecto mine. Exposures were examined in five different localities in that distance, including that on Styles' Brook. With one exception, the highest beds of conglomerate which could be found were very nearly at the same distance from the known or supposed position of the coal-seam, as on Styles' Brook; that is, at a distance of from 400 to 500 feet stratigraphically below it. The exception occurs at the St. George mine, where, on the small stream which crosses the strike of the conglomerate, and flows past the mine, the only exposures observed are at a vertical distance of from 1,600 to 2,100 feet below the coal-seam at the mine, or 1,150 to 1,650 feet below the supposed summit of the band. This position corresponds pretty closely with that of the lower conglomerate which is exposed near Weatherbee's mill, on Styles' Brook, and which I suppose to be separated from the main mass of conglomerate overlying it by a considerable thickness of shale, which the rock also resembles in lithological character. It is hoped that a more careful examination of this locality will supply additional facts. Stratigraphical distance between the coal and conglomerate.

At the Chiegnecto mine, situated about a mile to the westward of the St. George, the conglomerate is seen at about the same distance below the seam worked there as at the other points named; that is, about 450 feet. I am unable to say how far this conglomerate could be traced west of the Chiegnecto mine, as the time at our command did not permit of a further examination of the locality.

It seems tolerably clear that the Styles' Brook conglomerate constitutes the summit of the Millstone-grit formation, and therefore, the dip of the strata being south, that all workable seams of coal in the district should be looked for to the south of it. Hoping, however, to revisit the field Where workable coal-seams should be looked for.

during the coming spring, I shall leave the consideration of this point until I am in possession of additional facts.

In the few instances in which any exposures were observed of the strata immediately underlying the conglomerate, they were found to be chiefly chocolate-brown shales. There being usually a depression in the surface along the north side of the conglomerate, it seems probable that there is here a great mass of strata of this character, such as occurs on the Joggins coast, between the Productive Coal measures and that part of the Millstone-grit which furnishes the well-known Joggins grindstone.

Chocolate-brown shales.

The Styles' Brook conglomerate was also traced in an eastward direction for several miles; but, before describing its extension in that direction, I shall state some facts observed in regard to another important division of the rocks associated with the Productive Coal measures of this locality. It has been stated that there are two bands which from their position and peculiar lithological character are well suited to serve as guides to the distribution of the Productive Coal measures. The Styles' Brook conglomerate is one of these; the other is a band of massive grey sandstone which usually forms a conspicuous ridge along the south side of the area occupied by the Productive Coal measures—the dip being to the south. As far as observed, the colour is uniformly grey. It occurs in thick masses without any laminated structure, a character which distinguishes it from most of the Carboniferous sandstones, at least in the area considered in this report. It is consequently a good building stone, and in the district under consideration nearly all the quarries from which stone has been taken for the works on the Intercolonial Railway are situated on this band. It is noticeable that where the country roads cross it, they are invariably stony, differing in this respect from the other portions of the same roads. The band is easily recognized and traced across the country by these characters.

Grey sandstone above the Productive Coal measures.

Building stone.

There seems little doubt that the sandstone is the same as that which at the Joggins occurs at Ragged Reef, and which, according to Dr. Dawson, constitutes the base of the Upper Coal formation. The base of the band is about 4,500 feet above the summit of the Styles' Brook conglomerate, which is pretty nearly the thickness assigned to the Middle Coal formation at the Joggins, and it was traced from the Maccan River, below Athol, eastward to the Post Road. The interval between it and the conglomerate to the north is usually a little over a mile, and it is overlaid conformably by a great mass of softer strata consisting largely of fine red shale, of which mention will be made farther on.

Continuation of Coal Measures East of Styles' Brook.

The Styles' Brook conglomerate was traced eastward to a point on the east side of the Post Road, a distance of three-fourths of a mile from

Style's Brook. No exposures were seen beyond this, on the same east strike, though it is probable that by a more careful examination of the locality it might be traced some distance further. It is certain, however, that its extension in this direction is limited.

What is evidently the same band is well exposed to the south-eastward, on the upper part of the Little Forks River, about a mile above, that is, to the east of, the Post Road at Stewart's Inn. It has here about the same strike as on Styles' Brook, but the inclination is less; the dip being S.< 25°, while on Styles' Brook it is about S.< 45° to 48°. Some of it is reddish-brown, but much of it is precisely similar in colour and in all other respects to that on Styles' Brook. The thickness seen is only about 650 feet, but there is reason to believe that it is greater than this. Following it to the eastward on the strike, it was not exposed in place, but a ridge encumbered with great numbers of angular blocks of the conglomerate plainly indicates its course. This was traced for about two miles, at which distance the strike, which is at first east, becomes somewhat north of east. Conglomerate on the Little Forks River.

Under this conglomerate, on the Little Forks, there is red shale, precisely as on Styles' Brook. It is hoped that a more minute examination of this locality will give the means of defining more exactly the limits of the conglomerate, especially on the south side. Red Shale.

It has been stated that the grey sandstone which overlies the Productive Coal measures was traced from the Maccan River eastward to the vicinity of the Post Road. Following it eastward from the Maccan, it comes on the Little Forks from the north side somewhat less than a mile below Styles' Brook. At Styles' Brook it is partly on the north and partly on the south side of the Little Forks. Continuing to ascend the Little Forks, it is frequently exposed in the bed of the stream, which is probably about the middle of the band. In this way it was traced to a point about half a mile above the Post Road, which is within a few chains of the exposures of conglomerate already described. The relation of the two is such that the sandstone, if extended towards the conglomerate, would almost directly overlie it, leaving no space for the 4,500 feet of coal measures which should intervene. It is plain therefore, that if this conglomerate is the same as that on Styles' Brook, there must be a great fault between the most easterly exposure of the sandstone and the most westerly exposure of conglomerate. The supposition that it is the same is confirmed by the occurrence of the grey sandstone and its superincumbent red shales in their proper positions to the south. The sandstone forms a conspicuous ridge, which rising rather abruptly near the Post Road, at a point where it makes a sharp detour to the west to get round the end of the ridge, strikes boldly across the country, at first with a course about east-by-north, then north-east, to Chase Lake Brook, a dis- Grey Sandstone overlying the Productive measures. Probable fault. Chase Lake Brook.

tance of about three miles. It was not traced beyond this, though I believe, from information received from persons acquainted with the locality, that it might be easily followed at least several miles further. Owing to the prevalence of false bedding in this sandstone, the dip was ascertained only on Chase Lake Brook, were it is S. E. < 24°.

The resemblance of this sandstone to that which overlies the Productive Coal measures west of the Post Road, both as regards its lithological character and its associations, seems to leave little doubt of its being the same band. It follows from these facts, that the measures are cut by a fault, which crossing the Little Forks at the point already indicated—half a mile above the Post Road—and pursuing a course a little east of south, passes to the west of the west extremity of the sandstone ridge last described. The up-throw is to the east, and the amount of displacement must be several thousand feet. It follows also that the Productive Coal measures intervene between this sandstone and the conglomerate on the Little Forks River.

Course of fault.

Great Fault on North Side of Black River.

As already stated, the band of grey sandstone supposed to overlie the Productive Coal measures, east of the Post Road, is itself overlaid by red shales, similar to those which occupy the same position west of that road. These are tolerably well exposed on Chase Lake Brook. In descending this stream, in a south-easterly direction, toward the Black River, these shales, with bands of red and grey sandstones, are found to come in with great regularity, dipping about S.E. < 20°, and with a thickness of about 2,000 feet. At a point about fifteen chains north of the Black River they suddenly disappear, giving place to strata of an entirely different character from any noticed thus far in this Report. These are coarse, very friable sandstones, of a deep brick-red colour, with coarse conglomerates made up of very smooth pebbles of quartzite in a brick-red matrix. They occupy a narrow strip along the north side of the Black River, and also the bed of that stream from the mouth of Chase Lake Brook up to the Post Road, a distance of more than a mile. I had no opportunity to extend my observations beyond this distance. On the south side of the river there are deposits of gypsum, evidently extensive, and also limestone, which, however, I did not examine personally. These rocks will, no doubt, be found to belong to the Lower Carboniferous formation, and their occurrence here would imply the existence of an enormous fault, running in a north-east and south-west direction along the north side of this part of the Black River, and bringing up on the south-east side Lower Carboniferous rocks so as to appear to overlie about three thousand feet of Upper Carboniferous strata.

Red Shales on Chase Lake Brook.

Coarse sandstones and conglomerates of Black River.

Gypsum and limestone.

Enormous fault bringing up Lower Carboniferous rocks.

The dip of these sandstones and conglomerates on the Black River, appears to be about south-east, at a very low angle.

Upper Maccan and East Brook.

The rocks described thus far are all on the north side of the great Cumberland trough, the dip being uniformly to the south. Those occurring on the Upper Maccan, and on the East and Rattling Brooks, which will now be briefly alluded to, are on the opposite side of the synclinal, though near its centre. They dip, with considerable regularity, to the north, turning, however, to the north-west as the strata are followed on the strike eastward, which course would carry them to a position to the north-west of the coal seams at Springhill, and stratigraphically above them. The rocks of this district all belong to the Upper Carboniferous formation, and are chiefly fine red shales, with bands of reddish and greenish, mostly flaggy, sandstone, which appear to be thicker, and of more frequent occurrence, towards the base. There are also occasional bands of conglomerate, and sometimes thin beds of more or less arenaceous grey limestone. The lowest strata in this district, which are found in the extreme south-east part of it (the base being at the point where the Etter Road strikes the Maccan,) closely resemble those which on the north side of the trough immediately, overlie the band of grey sandstone supposed to constitute the base of the Upper Carboniferous.

Rocks on the South side of the Cumberland trough.

Upper Carboniferous.

In both cases there is a thickness of perhaps a thousand feet in which sandstones form a considerable proportion of the whole, overlaid by a great mass of fine red shales, with a much smaller proportion of sandstone. Whether there is here also an underlying band of massive grey sandstone, I am unable to say, but have reason to think it probable that there is. The dip at the end of the Etter Road, which was our starting point in the examination of this district, is about N.W. < 15°.

Direction of dip.

Following the strike westward, this dip gradually changes to north, in a distance of about two miles, and this is maintained with considerable regularity, as far west as our observations extended. Lower down on the Maccan and on the East Brook the dips conform well with those stated, but the inclination decreases northward towards the axis of the synclinal which crosses the Maccan about two miles above Athol. The breadth occupied by these rocks, at right angles to the strike, is about five miles, and the thickness, assuming that the succession of the strata is not interrupted by faults, of which there is no evidence, about 5,000 feet

Adding to this 1,000 feet for the supposed lower portion of the Upper Carboniferous, we have a total thickness of about 6,000 feet of strata above the Productive Coal measures, in this central part of the Cumberland trough. This far exceeds the thickness of the Upper Carboniferous seen on the Joggins, as given in Sir W. E. Logan's Joggins section, which is only 2,267 feet. I understand that Dr. Dawson has under consideration the question whether a portion of this great thickness should not be separated as Permian.

Thickness of Strata above the Productive Coal measures.

The rocks examined during the season, and described in this Report, exclusive of the supposed Lower Carboniferous strata on Black River, which I have no means of connecting stratigraphically with the others, may be grouped as follows, in ascending order :—

	Thickness.
Millstone Grit.	
I. Red shale, with fine-grained, reddish, flaggy sandstones, and occcasional bands of grey and greenish sandstone, say	1,000 feet.
II. Conglomerate, with pebbles of red syenite, and passing into coarse sandstone, interstratified with shale which is usually reddish-brown; the lower portion separated from the principal mass by a considerable thickness of red shale	1,500
Middle Coal Formation.	
III. Grey sandstone and shale, with seams of coal, only very partially exposed in this part of Cumberland, but no doubt the same as at the Joggins	4,500
Upper Coal Measures.	
IV. Massive grey sandstone, shewing much false bedding; forms a ridge	1,000
V. Red shale with reddish and greenish sandstones, also conglomerates, and thin beds of arenaceous grey limestone	5,000
Total thickness	13,000 feet.

I have the honor to be,

Sir,

Your most obedient servant,

WALTER McOUAT.

Montreal, May 1874.

REPORT

ON EXPLORATIONS AND SURVEYS IN

CAPE BRETON, NOVA SCOTIA,

BY

MR. CHARLES ROBB, C. E.,

ADDRESSED TO

ALFRED R. C. SELWYN, ESQ., F.R.S., F.G.S.,

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

SIR,—In the Report which I had the honor of submitting to you last year, regarding the work done in connection with the Survey in Cape Breton, it was stated that the facts collected up to that date, bearing directly upon the geological structure of the region, were not sufficiently numerous or detailed to enable me to present any part in a complete form. It was also intimated that my work up to that date had been devoted chiefly to the collection of materials for the construction of a topographical map on a large scale, and for a Report upon the collieries in operation in the Sydney coal-field, embracing a detailed description of the coal seams on which these works had been established. Such objects were deemed not only of the utmost economic importance at the time, but essential preliminaries to the systematic investigation of the structure.

Facts required.

Materials being collected for a map.

In the prosecution of the field-work of last summer, which was commenced on the 19th of June and continued to the end of October, I was assisted, as during the previous season, by Mr. Hugh Fletcher. As the districts visited lie within the limits of the inhabited part of the country, we were enabled to dispense with further assistance, except upon rare occasions. The distances traversed and measured during the season were approximately, along the coast and brooks 75 miles, and on the roads 80 miles. The bearings were obtained chiefly with the prismatic compass, and the distances by chaining, pacing, and micrometer telescope, as the circumstances seemed to render most eligible. In the examination of the extensive district embraced in the General Mining Association's property I have been greatly aided by the plans of their areas, which their superintendent, Mr. R. H. Brown, kindly permitted me to copy.

Field-work.

Measurements.

Aid from Mr. R. H. Brown.

The structural relations of the various members of the Productive Coal measures, and the identification of the seams throughout the entire field, regarding which a great diversity of opinion has been expressed by different authorities, were naturally the first objects which occupied my

attention. From the facts already established, it is believed, as stated in my former Report, that the entire eastern or Sydney coal-field, although subdivided into several minor or subordinate troughs, contains only one set of seams, the connection of which, where interrupted by bays or inlets, it is sometimes difficult to trace.

One set of seams in the Sydney coal-field.

One of the most important and obscure of these interruptions, namely, that which occurs under Sydney Harbor, and gives rise to the extraordinary and anomalous position and attitude of the measures on either side, has been noted and commented upon by Dawson, Brown, and all others who have made geological observations in this region. It was deemed advisable, at the earliest opportunity, to endeavor to trace the connection, if any such existed, between these disturbances and the structure of the Lower Carboniferous rocks, which are exposed at Point Edward and on the shores around the head of the harbor, and also at intervals in the adjacent district to the south. Accordingly, much attention was devoted in the early part of last season to this object; but further investigations and study are still required in order to determine the points at issue, which involve the working out of the structure over a large extent of country.

Disturbances of the measures in Sydney Harbor

The time occupied in this part of the field, extending from what I believe to be the summit of the Lower Carboniferous formation at Point Edward and Sydney Point, to its base, was about one month. I can only on the present occasion indicate the general results, which, however, are still liable to future modifications. The rocks consist of thick beds of red and grey argillaceous shale, sometimes calcareous, approaching in character to marls, and frequently without any trace of lamination or bedding; these beds often being copiously charged with nodules of limestone and argillaceous iron ore. With them are associated numerous beds of limestone, concretionary, laminated, and compact, and generally dark grey or almost black, and fetid; sometimes gypsiferous, and containing traces of galena and copper pyrites; and occasionally holding marine fossils of the ordinary Lower Carboniferous forms. Beds of red and grey micaceous sandstone, generally slightly calcareous, and often beautifully ripple-marked, are also of frequent occurrence in this formation, chiefly towards its summit, where also I have noted one bed of bituminous and highly calcareous shales between three and four feet in thickness, containing *Sigillaria*, *Lepidodendron*, fish scales, teeth, spines and coprolites, with *Naiadites*, and having a *Stigmaria* underclay.

Lower Carboniferous.

Fossils.

The promontory or tongue of land terminating at Point Edward divides the upper part of Sydney Harbor into two branches or arms, each being about one mile in average width. The Lower Carboniferous rocks, as above described, are developed over this tract, being brought to the surface by a low anticlinal, the axis of which runs in a north-easterly direction, the structure being complicated by a trans-

-verse anticlinal, also with very gentle dips. The opposite shores on either arm of the harbor are, for the most part, occupied by rocks of the Millstone Grit formation; the projecting point, however, on which the town of Sydney stands, is composed of the red sandstones, marls, and thin bedded limestones, which appear to be characteristic of the upper part of the Lower Carboniferous formation, and probably extend under a great part of the harbor, without any evidence of a break or fault. In so far as I have yet been able to ascertain, there seems to be no direct connection between the gentle undulations referred to and the contortions which would appear to be necessary in order to account for the attitude of the coal seams and associated strata at the Sydney and Victoria Mines respectively.

The series of rocks above described extends over a breadth, in the district referred to, of about four miles; and rests upon massive beds of coarse red conglomerate and sandstone, constituting a very prominent feature in the geology of Cape Breton, and which, on this and other accounts, may be entitled to rank as a distinct formation. The pebbles of the conglomerate are generally rounded, but sometimes angular; they vary in size from twelve inches in diameter downwards, and are composed of quartz, jasper, feldspar, quartzite, chloritic, hornblendic, and micaceous rocks, granite, syenite, diorite, red and green micaceous sandstone, and occasionally limestone. The attitude of these rocks, and consequently their thickness, is obscure; in the district above referred to they seem to occupy a breadth of two miles, giving place to the older metamorphic, or perhaps eruptive, rocks to the south. There is no doubt, however, that the occurrence of the latter at the point where they were observed in this district is merely local, and that the conglomerates are distributed to a much greater extent in that direction, on either side of a nucleus of the older rocks. With this proviso, and calculating from such observation and measurements as I have been able to make, I should estimate the thickness of the Lower Carboniferous rocks in this section, including the conglomerate, at 4,637 feet.

Red conglomerate.

Estimated thickness of Lower Carboniferous formation.

The locality where the older rocks were observed, namely, Morrison Brook, a small tributary of Grantmire Brook, at the head of the northwest arm of Sydney Harbor, was visited in consequence of a reported discovery of iron ore, which, however, was not verified by actual observation. Time was not afforded for other observations there, and I have thus few details to present on this point upon the present occasion. The prevailing rock observed was a red granulite or felsite, with a slaty structure, associated with masses of diorite highly charged with iron pyrites, and with numerous blotches of epidote. Specimens of a rock resembling talcose slate were also obtained from this locality, but its nature has not yet been accurately ascertained; also a red porphyritic rock, which, however, seems to belong rather to the base of the Lower Carboniferous formation.

Metamorphic or eruptive rocks.

Considerable time was devoted to the examination of another interesting district, where the contact of the Carboniferous with the older rocks is seen, namely, that included between Kelly Cove and Cape Dauphin, at the western extremity of the Sydney coal-field. The general structural features at this locality have been already noted by the late Mr. Edward Hartley, as quoted in your summary Report for 1871, pages 4–5. I have made measurements over the entire area, about three and a half square miles in extent, and have constructed four minutely detailed sections of the strata from the coal-measures to the syenite; but, as still more comprehensive observations are requisite in order fully to elucidate the structure, I shall reserve these details in the meantime. The existence of a fault or complication of faults here seems to be proved beyond a doubt, and the occurrence of a band of calcareous and magnesian rocks of varying thickness, between the Lower Carboniferous and Productive Coal-measures on the one hand, and the syenite on the other, is also clearly established.

Structure at Kelly Cove.

Faults.

Section.

The following section of the strata from the lowest bed of the productive measures to the syenite illustrates the general character and relative position of these rocks. The section, which is in descending order, is exposed in a brook cutting the beds at right angles to their strike:

1. Bluish argillaceous shale (Coal-measures).
2. Fine-grained, laminated, dolomitic limestone, with calc-spar between the joints.
3. Compact dolomitic limestone, carrying specks of galena and iron and copper pyrites; stained lead-grey in the joints.
4. Laminated, contorted, crystalline limestone.
5. Massive white dolomite.
6. Fine-grained, yellowish-white and blue, serpentinous and calcareous rocks, intersected by small quartz veins.
7. Red syenite.

A specimen of one of these rocks, probably taken from the same bed as that in which Mr. Hartley states that he observed rocks "which it would be impossible to distinguish from some of the Petite Nation serpentinous limestones, from which the best Eozoon was obtained," has been found on microscopic examination not to exhibit the peculiarities of this structure. The "broadly crystalline limestone," also mentioned by Mr. Hartley, and which I believe to be identical with that of bed No. 5 in the above section, proves on examination to be a dolomite. The following are the results of an examination of this rock by Mr. Hoffmann of the Geological Survey Laboratory:

Dolomite examined by Mr. Hoffmann.

"Structure coarsely crystalline; colour white; lustre vitreous; on exposure to the weather remains white or assumes a faint brownish tinge; here and there shews minute specks of pyrite. Specific gravity, 2.853.

"A section of the rock under the microscope exhibited small quantities of disseminated matter, not shewing the crystalline character of the carbonate.

"The powdered rock was digested for a short time in cold water, and the

filtered solution found to contain sulphate of lime and a chloride, probably chloride of sodium. When reduced to powder it did not effervesce with acetic acid, but was readily attacked by dilute hydrochloric or nitric acids, leaving a small quantity of a greyish-white residue. An examination of the residue left after treatment with dilute nitric acid shewed it to agree very closely in composition with some varieties of chlorite. It is most likely that the water given as hygroscopic is really part of the water of combination of the sulphate of lime; the quantities 0.272 and 0.071 calculated for the sulphate of lime present would equal 19.367 per cent.—about the quantity entering into the composition of gypsum. Neither baryta nor strontia could be detected.

" Analysis gave :—

Lime	30.419
Magnesia	20.754
Ferrous oxide	.314
Manganous oxide	.164
Carbonic acid	46.435
Sulphuric acid	1.042
Chlorine	.036
Water { hygroscopic	.272
Water { combined	.071
Insoluble residue	1.553
	101.060

OR,

Carbonate of lime	53.018
" " magnesia	43.583
" " iron	.506
" " manganese	.266
Sulphate of lime	1.771
Chlorine	.036
Water { hygroscopic	.272
Water { combined	.071
Insoluble residue	1.553
	101.076

INSOLUBLE RESIDUE.

Silica	.561
Magnesia	.489
Lime	.046
Alumina	.301
Ferrous oxide	.073
Water, combined	.151
	1.621

The new Campbellton coal mines, which are situated on this area, and were not in operation at the time of my first visit to Cape Breton, were reopened last year, and an opportunity was afforded me of inspecting the works. Appended to this Report is a detailed account of the present state

New Campbellton mines.

and prospects of these mines, the working of which will probably throw considerable light on the geological structure.

Iron ore

Immediately at the summit of the Lower Carboniferous rocks, and apparently marking in some places their junction with the next overlying formation, I discovered, in the immediate vicinity of Sydney, considerable deposits of a siliceous hematite, which seems to be sufficiently rich in iron to constitute a workable ore of that metal. Although the ore was found only in loose blocks, these were in such profusion and position, and of such dimensions and form, as to leave no doubt of their being near to the parent bed; especially as similar rocks, although not so rich in iron, were found in place at the same geological horizon in another part of the field. Should this ore on trial prove to be suitable for the manufacture of iron, either alone or in admixture with other ores, the situation of the beds in the immediate vicinity of the coal mines, railways, and harbor, may render this discovery of considerable economic importance. I may remark that in many other parts of this continent workable ores of iron have been found at this geological horizon.

Millstone Grit formation.

The rocks overlying the Lower Carboniferous, and intermediate between these and the Productive Coal-measures, and thus occupying a position analagous to that of the Millstone Grit of the English coal-fields, are well exposed in the natural sections afforded by Sydney Harbor, the Great Bras d'Or Entrance, etc. They consist, like their equivalents in other parts of the world, of a great series of sandstone beds, generally very coarse and almost conglomerate in character, and deeply stained with peroxide of iron; but sometimes of a bluish-grey color, finely grained, evenly bedded, and flaggy, and with occasional patches, but apparently no continuous beds, of argillaceous shale and coal. Some of the sandstone beds contain great quantities of obscure and fragmentary vegetable fossils, such as *Sigillaria, Stigmaria, Lepidodendron, Cordaites* and *Calamites;* the shales also contain the usual plant remains characteristic of the formation, although somewhat indistinct. In one bed or thin patch of carbonaceous shale I observed fish teeth, scales, spines, and coprolites. The Millstone Grit formation is distinguished throughout from those underlying and overlying it by the entire absence of calcareous strata.

Difficulty of obtaining reliable dips.

False bedding is prevalent throughout the whole series, insomuch that it is extremely difficult at any point to obtain a reliable observation of the dip. As regards the conditions of deposition of the entire formation, the appearances are all indicative of the existence of strong currents in various directions. Under these circumstances it has been found impossible, so far as my observations have extended, to subdivide the mass into its several beds, or to give any distinctive or characteristic description of its component parts. For the same reasons it is difficult, if not impossible, to arrive at any just or accurate estimate of its total thickness. From the best data

which I could obtain at Sydney Harbor, this may be provisionally stated at 4,228 feet on the west side, and 3,796 on the east, but it will probably be found to vary very much at different points.

The distinction between the Productive and so called Barren Coal-measures, or Millstone Grit series, in Cape Breton, seems to be well marked and unequivocal. In the latter, however, as has been remarked in other countries, coal seams occur, sometimes of workable dimensions, but differing from those in the productive measures both in quality and apparently in the conditions of deposition, and generally, so far as yet observed, wanting in persistency. From my observations of last season, and the identification of the coal seams thus far established, I am led to the belief that the discrepancy between Dr. Dawson's estimate of the thickness of the Productive Coal-measures, as displayed at the eastern end of the coal-field, and that at the Sydney mines, or western section (see Acadian Geology, pages 417–418), is due to his including in the former a large portion of the Millstone Grit; and that the lowest seams mentioned by him in the former locality actually belong to that formation. This is, in fact, the alternative hypothetically and doubtfully advanced by Dr. Dawson, and which appears to me to be the true one. Should these observations be confirmed by further investigation in the eastern section of the field, the result will be of the utmost importance in an economic point of view, as limiting the area within which coal seams of undoubted workable dimensions may be expected to occur.

Coal seams in the Millstone Grit.

Productive Coal-measures.

It has been already stated that the whole region occupied by the Productive Coal-measures in the eastern coal-field of Cape Breton is probably underlaid by only one set of seams, the continuity of which, however, is interrupted by bays or inlets. In a region where the natural exposures of the rocks—with the exception of those afforded in the sea cliffs—are so few and so difficult to correlate, the identification of the coal seams at different parts over the entire field becomes a matter of primary importance in the elucidation of the structure. For establishing this identity, neither the quality nor thickness of the individual seams, the partings by which they are generally more or less divided, nor even the organ remains found in the roof shales, are of themselves sufficient, as these are all liable to considerable variations.

Identification of coal seams.

For this purpose, as well as for comparison with other sections of the Coal-measures (as at the Joggins, etc.,) it was deemed necessary to make a minute and comprehensive survey of all the strata exposed in the sea cliffs. To this work a most valuable contribution had previously been made by Mr. Richard Brown in his elaborate section of the measures on the north-west side of Sydney Harbor, published in the Quarterly Journal of the Geological Society of London, vol. vi., page 115 *et seq.* Professor J. P. Lesley, of Philadelphia, had also measured portions of the coast section

Mr. Brown's section.

in the Little Glace Bay district, and published the results in the Journals of Assembly for Nova Scotia for 1862 and 1863.

In continuation and confirmation of this work I have made detailed measurements of the sections exposed in the sea cliffs, so far as they are accessible, in the western half of the field, and hope in the course of the present season to complete those in the eastern half. These sections were obtained for the most part by traversing along the base of the sea cliffs, and by direct measurement of the thickness of the beds as they come successively to the sea level. At the same time the nature of each stratum and its fossil contents were noted. The dips, as ascertained by the clinometer and compass, were checked whenever it was possible to do so, by recording the points in the traverse where the more conspicuous beds intersect the high water line.

Measurement of cliff section.

The results of the work thus far effected in this way, and herewith presented, consist of four complete and three partial sections of the Productive Coal-measures, so far as known in the district referred to. The sections are arranged in columnar form, drawn to a scale of forty feet to an inch, with the thickness of the coal seams and of the associated strata disposed in separate columns. They are taken at the following different points, viz.: 1. The Great Bras d'Or Entrance, Boulardarie Island; 2. The Sydney Mines and North Sydney; 3. The Victoria Mines and Low Point; 4. Low Point to Lingan; 5. The Little Bras d'Or Entrance, from the main seam to the Lloyd Cove seam; 6. Big Pond to Cranberry Head; 7 The New Campbellton mines. The four first mentioned sections include the whole of the Productive Coal-measures which are exposed from the Millstone Grit to the ocean. Nos. 5 and 6 are only partial sections, and are other wise incomplete, owing to the imperfect character of the exposures. No. 7 is the section exposed in a horizontal tunnel driven transversely through a part of the measures, where they are thrown into a nearly vertical position at the New Campbellton mines, near the contact of a mass of syenite.

Enumeration of sections.

In the Sydney mines section the total number of beds thus measured and represented amounts to 371, and in the other complete sections probably not fewer. They are classified into:—1. Argillaceous shale; 2. Arenaceous shale; 3. Red and green marl 4. Sandstone; 5. Underclay; 6. Limestone; 7. Black shale; 8. Coal. The aggregate thickness of all the beds at the Sydney mines section amounts to 1,838 feet 6 inches, of which 40 feet 8 inches are coal, and 14 feet 10 inches limestone. Most of the limestone beds contain fossils, and specimens were collected and have been placed in the hands of Mr. Billings for determination. The time occupied in the field at this work was about two months, during which most of the known outcrops of the seams inland in the western district were visited and located, so that we were enabled with considerable certainty to trace the seams across this portion of the field.

Classification of beds.

Fossils.

I may here state that the long disputed point as to the identity of the coal seams on the opposite sides of Sydney Harbor would appear to be set at rest by these investigations, which render it highly probable that the No. 3 and Ross seams of the Victoria mines are the equivalents respectively of the Indian Cove and Main seams of the Sydney mines. In their extension east and west also there seems no room to doubt the identity of the Indian Cove with the Northern Head seam at Lingan, and with the Blackrock and New Campbellton four feet seam at the Great Bras d'Or Entrance. Thus the small portion of the Productive Coal-measures exposed in the tunnel at New Campbellton, and represented in section No. 7, must be regarded as belonging to the lower and not to the upper portion of the formation, as conjectured by Mr. Hartley. Identity of seams.

By extending this system of observation over the eastern half of the field, it is confidently expected that all doubt as to the identity of the coal seams at different and distant points will be removed—a matter of considerable economic as well as scientific importance. It is also hoped that much knowledge will be incidentally obtained—for which, perhaps, no more favorable opportunity could anywhere be presented—as to the changes undergone by the various strata in their extension over great areas, and throughout numerous undulations. The results thus far obtained are reserved until the whole is completed. Change undergone by strata.

In addition to a large quantity of specimens, both of rocks and fossils, collected by myself, I have been so fortunate as to secure, through the kindness of Mr. A. J. Hill, Superintendent of the Emery mine, a fine collection of typical Carboniferous fossil plants, chiefly from the roof shales of the seam worked at that place. Among these Dr. Dawson has recognized and described some new species, and there are others which I understand he considers may be new, but which are not yet determined. In the roof of the slope of this mine I observed and sketched a magnificent specimen of the stump and roots of a *Sigillaria*, probably *Sigillaria Sydnensis*, the spreading roots occupying the full width of the slope (11 feet) and radiating from the stump with remarkable regularity. Collection of fossil plants.

At the date of my last Report operations at the Emery mine had only been commenced, but have since been prosecuted with extraordinary energy. A detailed account of the present condition of the mine is herewith presented. Emery mine.

In the course of last season I visited and made a preliminary reconnaissance of several places lying outside of and at some distance from the field of labor to which I had devoted special attention, and chiefly of such as were supposed to present objects of economic importance. Among these were:—1. The Iron Mines of Whykokomagh; 2. The Brine Springs situated half-way between Baddeck and Whykokomagh, on the lake shore road; 3. The Coal Mines of Broad Cove and Mabou; and, lastly, the Outlying districts.

Grand Narrows of Bras d'Or Lake, where a thick seam of coal was erroneously reported to have been found. The information thus obtained although by no means complete, will, I trust, be available in future and more minute examinations. Meantime I have secured specimens of the various productions from each of these localities, some of the more important of which are in the hands of Dr. Harrington for analysis.

Whykokomagh mine.

In regard to the Whykokomagh iron mines, I have to state that, although little has been done to develop them, it seems highly probable that they may prove to be of considerable economic importance, especially if the coals of the district are found to be of suitable quality for smelting the ore. This mining property is situated at the southern extremity of St. Patrick's Channel, a deep navigable bay or inlet of Bras d'Or Lake, about 24 miles from Baddeck, and 18 miles from Port Mabou.

Projected railway.

It will be traversed by a railway which is projected and will probably soon be constructed, connecting the coal mines of Broad Cove, Mabou, and other parts of Inverness county with a shipping port on the Strait of Canso, where it will connect with the railway system of the mainland of Nova Scotia and the rest of the Dominion of Canada.

Age and mode of occurrence of the ore.

The geological horizon and mode of occurrence of the metalliferous deposits seem to me to be analagous to those at the Acadia Mines, Londonderry, Nova Scotia, as described by you in the Report for 1872–73, pages 19–29. Operations have hitherto been confined to surface explorations and trial pits, to determine the size and quality of the lodes, which appear to be quite numerous. One of these, on which a shaft has been sunk on it to a depth of fifteen feet, has been stripped for a length of 800 feet, and gives every appearance of further extension. The bed or vein thus exposed is from ten to twelve feet in thickness, consisting of brown hematite, sometimes very pure but for the most part more or less mixed with quartz. * Specimens which have been subjected to assay are said to have yielded as high as 68½ per cent. of metallic iron, but I am unable to state the average yield from the whole quantity of ore excavated, amounting to 140 tons. The facilities for mining and shipping the ore or its products, and for landing fuel, etc., are of the most favorable description. The shaft above referred to is situated at an elevation of 330 feet above the lake, which is only between 500 and 600 yards distant, with sufficient depth of water to load moderate sized vessels close to the shore.

Facilities for mining and shipping.

Brine springs.

The brine springs referred to appear to issue from rocks lying towards the base of the Lower Carboniferous formation, and are situated on the

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* Specimens of ore brought by Mr. Robb from Whykokomagh have been examined by Dr. Harrington. They consisted of a mixture of micaceous iron ore and magnetize with a considerable proportion of siliceous matter. One specimen contained 41.28 per cent of metallic iron, and another 42.64 per cent. of iron and 0.26 per cent of phosphoric acid. A. R. C. S.

north side of the Little Narrows of Bras d'Or Lake, between the shore and the road, about 12 miles south-west of Baddeck, on land belonging to John Watson, miller. Here several saline springs of more or less strength occur in close proximity over an area of about twelve acres of flat marshy land. Much hydrated peroxide of iron is deposited in the water courses, the odor of sulphuretted hydrogen pervades the atmosphere in the vicinity, and the vegetation is destroyed around all the springs. The strongest spring, from which about a gallon was taken for analysis, appeared to me to discharge from 100 to 200 gallons per minute. It was stated that by evaporating in two common iron pots, each containing about three gallons, from two to three bushels of salt were made per day. I was further informed that it had been proposed many years ago to establish works for the manufacture of salt at this place, and that machinery had actually been ordered for that purpose, but I am not aware for what reasons the undertaking was abandoned. The following are the results of an examination, by Mr. Christian Hoffmann, of the sample referred to above:—

" When received the brine had a brownish tinge, due to suspended ferric hydrate, which, after the water had been standing for some time, settled down as a reddish-brown sediment, leaving the supernatant liquor perfectly bright and colorless; this had a pure saline taste and was perfectly neutral: boiling caused a deposition of sulphate of calcium. The specific gravity was 1043.1. Characters of brine.

" The filtered brine contained in 1000 parts:

Sodium	19.9423
Potassium	0.1019
Calcium	1.6709
Magnesium	0.0403
Iron	absent
Alumina	traces
Chlorine	30.9585
Sulphuric Acid (SO_4)	4.0162
Silica	traces

OR,

Chloride of sodium	50.6881
" potassium	0.1942
" magnesium	0.1593
Sulphate of calcium	5.6810
Alumina	traces
Silica	traces
	56.7226

" The suspended matter for 1,000 parts of the brine amounted to 0.0068 and this contained 0.0054 of ferric oxide which had, in all probability, at one time entered into the composition of the brine as ferrous carbonate."

COAL-FIELDS OF INVERNESS COUNTY.

The coal-fields of Broad Cove and Mabou, in the county of Inverness, comprise respectively small and isolated patches of the Productive Coal-measures. Together with those of Port Hood and Chimney Corner, in the same county, which were not visited on the present occasion, they appear to constitute all that remains visible of that formation on the western side of the Island of Cape Breton. These minor coal-fields are bounded, at a short distance inland, by Lower Carboniferous rocks, which likewise separate them from each other along the coast; but they may probably be regarded as portions of one basin which is now for the most part beneath the ocean. The occurrence of the Lower Carboniferous rocks between these detached portions of the overlying formation, indicates the existence of a series of breaks and undulations in the measures, and accordingly the coal seams and associated strata are generally found to be in a more or less disturbed condition.

Coal-field of Broad Cove.

The coal-field of Broad Cove, however, appears to partake less of this character than the others named, the Productive measures there extending to a considerable distance inland, and dipping at a moderate angle seaward. The total area occupied by these measures on the land at this place, in so far as my very cursory examination warrants me in stating, may be estimated at about five square miles, which, together with some adjacent lands, and a large extent of sea area, amounting in all to twenty square miles, are now held, partly under lease and partly under a license to search, by Mr. H. E. Ross of Sydney, Judge McCully, Hiram Blanchard, Esq., and their associates.

The rocks, consisting of the usual alternations of sandstone and shale, with several associated seams of coal, appeared to dip N. 10° E. $< 10°$—$20°$, with a strike nearly parallel to the sea shore. As little or no work has yet been done throughout these areas to develop the coal seams, and as the measurements made by me are only approximate, the information I have to convey on the present occasion must be regarded as very general.

Enumeration of the seams.

The following is an enumeration of the coal seams in descending order, so far as observed by me, with their approximate thicknesses and those of the interposed strata:

1. A three feet seam, near the shore.
2. A seven feet seam with 376 feet of strata intervening
3. A four and a half feet seam with 437 feet of strata intervening.
4. A three feet seam with 303 feet of strata intervening.
5. A three feet nine inches seam with 32 feet of strata intervening.

Between seams Nos. 1 and 2 another, said to be five feet in thickness, is reported to have been found, but was not seen by me, although its existence is regarded as probable. Exclusive of that last referred to, the

total quantity of coal contained in these seams may be roughly estimated at 26,000,000 tons on the land areas, and 34,000,000 tons additional if worked under the sea for a distance of half a mile from the shore. The amount available under the sea may be very greatly increased by extending the workings to a greater distance from the shore. Estimated quantity of coal

Samples from most of these seams were taken for analysis and are now in the hands of Dr. Harrington for that purpose.* Judging from appearance, the coal, which is altogether of the bituminous kind, seems to be of excellent quality. From the manner in which it burns in a common fire I should judge it to be peculiarly free from liability to produce the dense black smoke which is an objectionable feature in the burning of the coals both of the Sydney and Pictou fields generally. Quality of the coal.

The development of these mining properties has hitherto been retarded by the want of a port of shipment, that part of the coast where they are situated being very open and exposed, and on that account difficult of access. The projected railway, to which reference has been made above, will, if constructed and put in operation, effectually obviate this difficulty. Railway accommodation.

MINING STATISTICS.

In addition to the ordinary field and office work in connection with the survey, considerable attention has been devoted during the past two winters to the collection of Mining Statistics for the entire Dominion. I have endeavored to carry out this work in prosecution of the system which was inaugurated by you in 1869, the results of which for the three subsequent years have been published in the Report for 1871-72. I am sorry to state that the deficiency in the returns, the scantiness of which up to that date we had occasion to regret, has been still more marked during the last two years; insomuch that it has been found impossible to compile an annual statement at all approaching completeness. It is unnecessary to detail the causes which may be assigned for this deficiency. The number of printed forms issued for the last two years has been 160; the number returned only about 50. This is partly due to the fact that there has recently been a temporary suspension of operations at many mines. Under these circumstances it is thought advisable that the publication of the Tables should, in the meantime, be only triennial. Deficiency in the returns.

I have the honor to be, Sir,

Your most obedient servant,

CHARLES ROBB.

Montreal, May, 1874.

* The analyses will be given in an appendix.

SUPPLEMENTARY REPORT ON COLLIERIES IN OPERATION.

I.—NEW CAMPBELLTON MINES.

Work at these mines having been suspended at the time of my first visit to Cape Breton, in 1872, they were not included in the general account of collieries then in operation. In the fall of last year, however, they were re-opened, and have continued in operation ever since; and I propose to supplement my former Report by an account of their present condition. A special interest attaches to this colliery on account of its geological position, as noticed in your Summary Report for 1870-71, page 4.

Reference to previous report.

The works have been carried on for the last twelve years, to a limited extent, and with occasional intermissions, by the proprietor, Hon. Charles J. Campbell, of Baddeck, who has displayed much energy and enterprise in the face of many adverse and difficult circumstances. The property comprises three square miles, a small proportion of which is sea area, but easily accessible from the land. It is situated on the northern side of the Great Entrance of the Bras d'Or Lake, a very extensive and deep arm of the sea stretching far into the interior of the Island of Cape Breton, and lies at the north-western extremity of the Sydney coal-field, and about thirteen miles distant on the course of the beds, from the Sydney mines. Most of the coal seams of the Sydney mines are traceable throughout the whole of this distance, and, although at the Great Bras d'Or Entrance their direct continuity seems to have been interrupted, and their coursede flected considerably to the west, it is nevertheless believed on good ground that some of the most important seams of the district underlie the New Campbellton property in a basin shape, with their outcrops comprised entirely within the area.

Situation of the property.

The surface of the ground throughout this area is for the most part very rough and irregular, thus rendering the tracing of the seams, and their identification at different points, a matter of some doubt and difficulty. The western boundary of the property is skirted by a high ridge of syenite upon the flank of which three coal seams, one of six feet, another of two feet, and another of four feet in thickness, repose in a nearly vertical attitude. The whole group is included within a thickness of 110 feet, the two feet seam being between and about equally distant from the six and four feet seams, and the lowest not more than 500 feet from the contact of the syenite. These have been traced, running in a perfectly straight course N. 55° E., over a length of 100 chains, or one mile and a quarter; and the four feet and six feet seams have been partially worked for a length of 560 and 53 yards, respectively, by a tunne, or adit, driven across the strike, and connecting both seams transversely at or near the natural drainage level. A considerable quantity of coal has

Ridge of Syenite.

Vertical coal seams.

Tunnel.

been obtained here, chiefly from the four feet seam, by overhead workings in the ordinary bord and pillar method, above the levels, which are about 150 feet from the surface.

At the distance of about three-quarters of a mile southward from the tunnel a seam of coal, four feet five inches in thickness, and dipping E.< 12°, crops out, and has been worked to some extent by a slope. Although its attitude and course are very different from those of the seam cut in the tunnel, there can be little doubt that the two openings are on the same seam, and that the area included within and beyond the outcrops is in the form of a basin, which is underlaid by this, and by the accompanying coal seams, to the extent of their respective outcrops. In confirmation of this view, it is found that the seams themselves and associated strata, where seen along the side of the mountain to the southwest of the tunnel, instead of maintaining the straight course which they have in the opposite direction, gradually bend round to the south, with diminishing dip, to meet the seam worked at the slope. Coal seam at low angle.

The four feet seam has been traced, partly by underground workings and partly by surface explorations, for a distance of nearly a mile across the the property, and extends, no doubt, over its entire breadth. The underlying seams have been exposed at intervals to a sufficient extent to render it probable that they will also be found throughout in their proper relative positions. Thus, supposing these three seams to maintain their thickness, and to be unaffected by faults, they will underlie, at a moderate and easily workable depth, an area of 1,000 acres, and contain 18,000,000 tons of coal, exclusively of the vertical portions of the seams, which may be estimated to contain 8,000,000 or 10,000,000 tons additional. It is proper to mention, however, that the six feet seam, where cut and partially worked at the tunnel, is irregular in thickness, and may not prove to be workable throughout its whole extent; but, on the other hand, there are evidences of the existence of other seams lying both above and below those specified. It is also worthy of remark that, although that part of the area where the seams have been tested is in a disturbed condition, there is still a large portion of it in which the strata appear to be perfectly undisturbed, and where the coal seams may reasonably be expected to partake of the same regularity. Estimated quantity of coal in the area. Irregularity of six feet seam

The six feet seam at and near the tunnel yields a bright, clean, bituminous coal; it does not, however, as already remarked, maintain its regular thickness in the exposures hitherto made. The two feet seam, wherever it has been exposed, is also a remarkably fine and pure bituminous coal, and is very regular. The four feet seam, from which by far the largest amount of coal has hitherto been extracted, having been worked, both at the tunnel and at the slope, very near the crop, is found to be somewhat contaminated with earthy and other impurities, which perhaps will dimi- Quality of the coal.

ish as the seam is worked farther to the deep, and in those parts of the area where the strata are undisturbed.

Surface Works.—No machinery has hitherto been employed at the tunnel workings, although it will be requisite in the event of operations being resumed there. . At this part of the property there are three dwelling houses, a blacksmith's shop, coal screens, etc. At the slope there is a 10 horse-power steam engine, with vertical boiler and oscillating cylinder, for hoisting, and a powerful "Cameron" pump, supplied with steam from a separate boiler. There are also eleven double houses for miners, storehouses, blacksmith's shop, powder magazine, coal screens, etc.

Buildings, machinery, &c.

The coal obtained at these mines is shipped from Kelly Cove, an inlet or bay in the Great Entrance of the Bras d'Or Lake, forming a deep, capacious, and sheltered harbor, well adapted in every respect for a shipping place. This harbor is about three miles from the Atlantic Ocean, with which it is connected by a broad and deep channel.

Shipping place.

Railway.

There is a good, though light, railway from the slope to the wharf, a distance of a mile and a quarter, with descending grade for the most part. The gauge of the railway, which is capable of being worked by a locomotive, and is about to be supplied with one, is 3 feet 6 inches, with T. rails, 35 pounds to the yard. The railway is equipped with 40 or 50 trucks or wagons, each of the capacity of a ton and a half From the slope to the tunnel a tramway has also been graded and laid with strap rails on longitudinal timbers; this part of the road, however, has been allowed to fall into decay in consequence of the discontinuence of the tunnel workings.

rucks.

Wharf.

At the shipping place at Kelly Cove there is a substantially built wharf with all requisites, shute, etc.; and capable of accommodating at one time three vessels for loading coal, and an equal number discharging cargo. The depth of water at the wharf is sixteen feet, and could be easily increased to twenty feet, by extending it a little farther from the shore. There are also at this point storehouses, managers' houses, blacksmith's and wagon repair shops, etc.

Underground Works.—During the time these mines have been in operation, the coal has been obtained partly from the tunnel and partly from the slope workings. The extent of the former has already been specified; they were discontinued at that point chiefly in consequence of the limited extent of the seam available overhead, and until preparations could be made for sinking below the level of the tunnel. The slope has been driven 200 feet on the angle of dip; levels have been extended 385 yards north-west and 140 yards south-east; and the coal, of which a thickness of four feet is available, has been extracted to the rise in the ordinary pillar and bord system. The aggregate quantity shipped from the date of commencement to that of temporary suspension in 1867—all of which met

Tunnel workings.

Slope workings.

Production.

with a ready market—is 27,066 tons large, and 2,187 tons small coal, besides that used at the works.

Operations were resumed last summer at the slope by sinking further to the deep, and are said to have been attended by a marked improvement in the quality and available thickness of the seam, with a diminution in the angle of dip. From the last accounts received from the mine, it seems reasonable to expect that, with an additional 200 feet of sinking on the slope—a work which is now in progress—the seam, which has hitherto been worked altogether too near the crop, will yield from four and a half to five feet of good coal.

II.—EMERY MINE.

The extent, situation and general conditions of the property on which this mine has been established are described in the Report of 1872-73, page 267–269, where it is also stated that mining works were commenced in the autumn of 1872. Since that date the colliery has been brought into productive and prosperous operation, through the agency of Mr. Gisborne, and under the immediate superintendence of Mr. A. J. Hill. Recently the whole of the mining areas enumerated on page 270 of my report above cited, together with the Glasgow and Cape Breton railway connecting them with Sydney Harbor, have been amalgamated under one Company of English capitalists, called the "Glasgow and Cape Breton Coal and Railway Company," of which Mr. Gisborne has been appointed local general manager. The extension of the Glasgow and Cape Breton railway to the Port of Louisburg, the advantages of which are referred to on the same page of the Report of last year, forms also a part of the operations of this company; and this work is now actually under construction, and expected to be completed in the course of another year.

New Company

Railway accommodation.

Surface Works.—The seam, hitherto called the Ross, but now, in order to avoid confusion, proposed to be called the Emery seam, has been proved by the workings to vary from four feet nine inches to five feet ten inches in thickness of excellent coal, dipping N. 49° 30′ E $<$ 5° 12′ or 1 in 11. Access to the underground workings is afforded by a slope 11 feet wide by 5 feet 5 inches in height. Hitherto the slope has been worked by two portable winding engines of about 50 horse combined power, with two winding drums, 5 feet in diameter, multiple gear 3½ to 1, and steel wire rope 2½ inches in circumference. There is also a 16-horse portable engine for driving the machinery of a repair shop. These portable engines have only been in use temporarily, being about to be replaced by an engine and machinery the counterpart of those described in the notice of the Reserve Mine (Report for 1872-73 page 267.) The mine is drained by two 7 inch Cameron steam pumps, one of 12 inches and the other of 20 inches stroke; also by a vertical double plunger pump, with 12 inch steam cylinder, and plunger 5 inches in diameter and 10-inch stroke.

Machinery.

Drainage

Underground Works.—The slope has been driven about 1,150 feet on the full dip of the seam, and the main levels have been extended 750 feet on the north-west side and 500 feet on the south-east side of the slope. The thickness of the seam at the former end is four feet nine inches, and at the latter five feet ten inches. The seam is worked on the usual bord and pillar system, the pillars being left 45 feet long and 18 feet wide. The gauge of the railways underground is 2 feet 2½ inches, laid with bridge rails, 18 pounds to the yard for the level roads and slope, and 14 pounds for the working rooms and bank. The number of tubs at present employed is 90, their capacity 24·5 cubic feet. There are at present 60 coal-cutters employed in the mine, and the total number of hands in the pit and on the bank may be about double that number. Six horses are used underground and about the same number on the surface. There are 18 double houses for miners, besides many other buildings connected with the establishment.

Extent of workings

Underground railways

Men employed.

Production.—The capability of this colliery with the present appliances, and at the present rate of production, is from 220 to 230 tons per day, and the total amount sold during last year 14,000 tons, most of which was, of course, obtained before the mine had been brought into full operation. The total production up to the present date is about 40,000 tons. The coal has been sold chiefly in Montreal, New York, and to merchant steamers calling at Sydney, and has given good satisfaction.

CHARLES ROBB.

MONTREAL, May, 1874.

APPENDIX TO MR. ROBB'S REPORT.

NOTES ON SPECIMENS OF COAL FROM THE INVERNESS COAL-FIELD, CAPE BRETON.

BY

MR. CHRISTIAN HOFFMANN.

3 feet seam

No. 1. * "3 feet seam."

Does not soil the fingers; colour black; lustre bright; banded, the successive layers differing in lustre; powder black with a faint brownish tinge; fracture uneven; contains iron-pyrites visibly disseminated through it; when boiled in a solution of caustic potash it communicated a brownish-yellow colour to the solution.

By slow coking the under portion of the powder alone was slightly sin-

* The numbers here, with the exception of 3, correspond with those of the seams given on page 180.

tered, the middle and upper portions remaining pulverulent. Fast coking gave a compact and hard coke of a steel-grey colour and bright lustre. Ash reddish-brown.

The analysis gave:

	Slow coking.	Fast coking.
Water	7.92	7.92
Volatile combustible matter	27.56	34.71
Fixed Carbon	53.75	46.60
Ash	10.77	10.77
	100.00	100.00
Coke	64.52	57.37
Ratio of volatile to fixed combustible	1 : 1.95	1 : 1.34

No. 2. "7 feet seam."

7 feet seam.

Does not soil the fingers; colour black; lustre bright; banded, the successive layers differing in lustre; planes of cleat distinct and at right angles to the plane of bedding; fracture uneven; powder black; when boiled in a solution of caustic potash it imparted no colour to the liquid. The specimen contained layers of a honey-yellow coloured, translucent and brittle mineral, which upon examination proved to be zinc blende. Dr. Harrington recently detected this mineral in a specimen of clay iron-stone from Pictou County, the first instance in which it had been found in the Carboniferous of Nova Scotia. The occurrence of zinc blende in this coal is, therefore, interesting as shewing that it not only occurs in the clay iron-stone, but likewise in the coal itself.

Zinc blende with coal.

By slow coking the under portion of the powder was slightly sintered, the rest remaining pulverulent. Fast coking gave a compact and hard coke of a steel-grey colour and bright lustre. Ash very pale grey.

During the process of fast coking and just prior to the completion of the operation there occurs invariably a slight explosion, probably from the sudden escape of confined gases. None of the other coals here examined comported themselves in this manner, although Dr. Harrington has observed the same peculiarity in several coals from the Sydney coal-field.

Deportment of coal during coking.

An analysis of this coal gave:

	Slow coking.	Fast coking.
Water	4.02	4.02
Volatile combustible matter	20.17	25.39
Fixed carbon	70.41	65.19
Ash	5.40	5.40
	100.00	100.00
Coke	75.81	70 59
Ratio of volatile to fixed combustible	1 : 3.49	1 2.56

5 feet seam.

No. 3. "5 feet seam."

Does not soil the fingers; colour black; lustre bright; banded, the successive layers differing in lustre; planes of cleat very marked and inclined to the planes of bedding at an angle of about 60°; fracture uneven; colour of powder black with a faint brownish tinge; iron-pyrites visibly disseminated through the coal. Boiled in a solution of caustic potash it imparted to the liquid a brownish-yellow colour.

By slow coking the particles are only very slightly sintered together. Fast coking gave a compact and hard coke of a steel-grey colour and a bright lustre. Ash reddish-brown.

Analysis gave:

	Slow coking.	Fast coking.
Water	7.78	7.78
Volatile combustible matter	27.67	34.51
Fixed carbon	52.87	46.03
Ash	11.68	11.68
	100.00	100.00
Coke	64.55	57.71
Ratio of volatile to fixed combustible	1 : 1.91	1 : 1.33

3 feet seam.

No. 4. "3 feet seam."

The characters of this coal are similar to those just given for number 3, except that the planes of cleat are at right angles to those of bedding, and that the ash is brownish-grey in colour.

Its analysis gave:

	Slow coking.	Fast coking.
Water	8.49	8.49
Volatile combustible matter	28.23	36.82
Fixed carbon	56.99	48.40
Ash	6.29	6.29
	100.00	100.00
Coke	63.28	54.69
Ratio of volatile to fixed combustible	1 : 2.01	1 : 1.31

3 feet 9 inches seam.

No. 5. "3 feet 9 inches seam."

The description given under No. 3 is applicable here, except that the planes of cleat are at right angles to those of bedding, and the ash of a light brownish-grey colour.

Analysis gave:

	Slow coking.	Fast coking.
Water	8.45	8.45
Volatile combustible matter	28.36	36.52
Fixed carbon	56.94	48.78
Ash	6.25	6.25
	100.00	100.00
Coke	63.19	55.03
Ratio of volatile to fixed combustible	1 : 2.00	1 : 1.33

On glancing over the foregoing analyses, it will be seen that while Nos. 1 and 3, and 4 and 5, respectively, agree most closely, yet the four do not, apart from the percentage of ash, differ very materially in composition: they contain a rather large percentage of water, and their powders when boiled in a solution of caustic potash communicate to the solution a brownish-yellow colour, so that, although belonging to the Carboniferous, they approach in character to brown coal. Coal No. 2 stands by itself; it contains far more fixed carbon, and less water than the others, and its powder, when boiled in solution of caustic potash, imparts no colour to it. Its large proportion of fixed carbon is a point worthy of notice.

Approximation in characters to brown coal.

CHRISTIAN HOFFMANN.

NOTES

ON THE

IRON ORES OF CANADA AND THEIR DEVELOPMENT,

BY

B. J. HARRINGTON, B.A., PH.D.

ADDRESSED TO

ALFRED R. C. SELWYN, ESQ., F.R.S., F.G.S.,

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

MONTREAL, May, 1874.

SIR,—Much has been written about the iron ores of Canada, not only by officers of the Geological Survey, but by others interested in the development of the country's resources. The information, however, is to be found mainly in scattered reports and papers, many of which are not readily accessible to the general public. In the accompanying report I have endeavoured to bring together concisely some of the more important facts which they contain, at the same time supplementing them, when possible, with the results of my own more recent observations.

Sources of information.

During the past summer a large number of iron localities were visited, and valuable collections of the ores made, which are now available for the Museum. The information contained in the last part of the report, under the head of "Economic Considerations," was partly obtained during this tour among the mines, and partly through the medium of correspondence subsequently carried on. If it is incomplete, the difficulty of obtaining it must be borne in mind.

Acknowledgment of assistance.

To Principal Dawson, as well as to many other gentlemen whose names are given in the report, my thanks are due for much valuable assistance and information.

I have the honour to be,

Sir,

Your most obedient servant,

B. J. HARRINGTON.

REPORT.

The iron ores of the Dominion have a wide range, both geographical and geological. From Vancouver Island on the west to Cape Breton on the east they occur at varied intervals; little, however, being known of their extent or importance, except in the provinces on the eastern side of the continent. Distribution of iron ores.

From the Laurentian days down to the present moment, processes of concentration, both chemical and mechanical, have been in operation, often resulting in the formation of beds and veins of ore. The processes have doubtless, to a certain extent, differed in kind, and have operated under more or less favourable conditions, and the ores, subsequently to their deposition, have frequently been subjected to agencies, depriving them of their original characters, so that it is not surprising to find them differing widely in chemical composition and physical characters. They may, however, be classified as follows:— Concentrating processes. Classification of ores.

I.—ANHYDROUS OXIDES.

1. Magnetic Iron Ore or Magnetite.
2. Hematite, including crystalline and earthy varieties.
3. Titanic Iron Ore.

II.—HYDROUS OXIDES.

1. Limonite or Brown Hematite.
2. Bog Ore.

III.—CARBONATES.

1. Spathic Ore.
2. Clay Iron-stone.

MAGNETIC IRON ORE.

The most important deposits of this ore occur in rocks of Laurentian and Huronian age, but it is also found in rocks which have been referred to the Lower and Upper Silurian, as well as in the Devonian and the Trias. The iron sands of the Gulf of St. Lawrence, moreover, give us examples of deposits of more recent date, and form one of the best possible illustrations of the great concentrating processes carried on by Nature. Age of magnetites.

The mode of occurrence, mineral associations, and chemical composition of some of these ores will now be considered; and since a dividing line cannot, in our present state of knowledge, be in all cases drawn between the Laurentian and Huronian, the magnetites which probably belong to both these great divisions will be classed together. Laurentian and Huronian magnetites classed together.

MODE OF OCCURRENCE AND MINERAL ASSOCIATIONS OF LAURENTIAN AND HURONIAN MAGNETITES.

So few of our mines have been extensively worked that opportunities for studying the character of the deposits are exceedingly limited as compared with those afforded in Norway and Sweden, and also in New York and New Jersey. There seems, however, little doubt that, while the larger and more important deposits, such as the "big ore-bed" in Belmont, are interstratified beds, true veins of magnetic iron ore also occur.

Beds and veins.

Foley mine.

At the Foley mine in the township of Bedford, the country rock, which is a diorite shewing little or no indication of bedding, is cut not only by the deposits of magnetite, but also by veins of coarsely crystalline calcite, the two minerals being in some cases associated. No one would hesitate in calling the deposits of calcite veins, and the magnetite, so far as could be observed, occurred in quite an analogous manner. The magnetite, moreover, was found here in large octahedral crystals, the axes of which are often more than an inch in length; these crystals are somewhat rude, but their surfaces are covered with smaller ones which though minute are well formed. In the undoubted beds, the magnetite, so far as I have observed, is generally granular or massive, but does not occur in large crystals of definite form. The mere occurrence of crystals, however, would in itself be no proof of the deposit being a vein.

Octahedral crystals of magnetite.

Again, on lot 6, range 8, of Marmora, near the "marsh ore-bed," an opening has been made in a deposit of magnetite; the opening is too small to give any idea of the true nature of the deposit, but the association of minerals is such as is usually found in veins rather than in beds. The minerals are calc-spar, fluor-spar, feldspar, hornblende, spathic iron, cubic pyrites, magnetic pyrites, copper pyrites.

Supposed vein.

Veins in Ross and Buckingham.

Sir William Logan mentions the occurrence of veins of magnetite in the crystalline limestone of Ross, opposite Portage du Fort, (Geol. of Can., 1863, p. 37), and also a vein in Buckingham composed of large cleavable masses of feldspar and magnetite (Ibid. p. 20.).

"Granitic dyke" in New Jersey.

In the Report of the Geological Survey of New Jersey for 1873, p. 27, "a coarse crystalline granitic dyke" is mentioned, and stated to be composed of feldspar, quartz and magnetite. It may be, however, that this is in reality a segregated vein and not a dyke.

The magnetic ores of New Jersey in many respects resemble our own. The workable deposits are now regarded as of sedimentary origin, though formerly believed to be eruptive.* The latter view was also taken by Sir Roderick Murchison as to the origin of some of the rich deposits of magnetite in the Urals †; and many of the deposits of magnetite in Norway and

Eruptive origin of deposits.

* Geology of New Jersey, 1868, p. 533, and also Report for 1873, p. 18.

† Geology of Russia, pp. 372 and 380.

Sweden have been considered as eruptive by Durocher and others. None of the Canadian magnetites, so far as I am aware, have ever been regarded as eruptive, at least by the officers of the Geological Survey.

Origin of sedimentary magnetites.

Concerning the origin of our sedimentary magnetites, the question arises as to whether they were originally deposited as such, or in some other form, and afterwards altered to magnetite. It seems possible that, in some cases, beds may have been formed by the accumulation of iron sands, just as they are forming in the Gulf of St. Lawrence to-day, the material being derived from the disintegration of pre-existing crystalline rocks. Such beds we should expect to contain not only magnetite, but ilmenite, and it is well known that in many cases ores on being pulverised may be more or less completely separated into a magnetic portion containing little or no titanic acid, and a non-magnetic portion consisting essentially of ilmenite. It seems, however, probable that in general their origin has been similar to that of the modern bog and lake ores. Deposits of magnetite, as a rule, do not continue of uniform thickness for any great distance like the enclosing rocks, and this is just what might be expected if we suppose them to have originally occurred as bog or lake ores which accumulated in local hollows or depressions. No ore, moreover, would be more readily converted into magnetite than bog ore, on account of the considerable proportion of organic matter which the latter contains.

Curious deportment of bog ore.

In this connection may be described a very simple but interesting experiment tried with a specimen of bog ore from L'Islet, containing about 22 per cent. of water and organic matter. The pulverized ore was placed in a platinum crucible, and heated for an hour at a temperature of 190° F. At the end of that time it had parted with its combined water, or at any rate with sufficient to cause the colour to change from brown to bright red. It still, however, retained organic matter, and on heating for a few minutes in a tightly closed crucible, and at a temperature considerably below redness, a reduction of the peroxide ensued, and a black strongly magnetic powder was obtained, apparently consisting of magnetic oxide, and not of metallic iron, as it occasioned no precipitation of metallic copper in a solution of the sulphate. The cover was now removed from the crucible and a red heat given, when in a short time the powder again became red, or rather purplish-red, and non-magnetic. Finally, the heat was raised a little higher (to bright redness), and soon the powder became black and strongly magnetic, having apparently parted with a portion of its oxygen. These changes are instructive, for while brought about in the laboratory they might take place in nature. They shew, too, that in some cases magnetites may have been formed from such ores as bog ore at comparatively low temperatures, the reduction being due to the organic matter of the ore.

That a magnetic oxide should be converted into a non-magnetic oxide,

as described above, is a curious fact. It is generally stated also that peroxide of iron requires a white heat to convert it into magnetic oxide, but the heat of an ordinary Bunsen burner has been found, to readily convert limonites, even when free from organic matter, into magnetic oxide.

Remarks by Durocher on the rocks of Scandinavia containing magnetic iron ore.

Durocher, speaking of the Scandinavian ores, says: "The deposits of magnetic iron ore occur in rocks of very varied character, and it does not appear that their richness is influenced by the nature of these rocks; some are enclosed in ordinary gneiss, others in quartzose, micaceous or hornblendic schists, or else in calcareous beds; others are found at the line of contact of granite and gneiss, rarely in the granite itself; there are some which form part of dioritic or hornblendic masses enclosed in the gneiss."

Rocks containing magnetite in Canada.

Most of what Durocher states here might be said with equal truth of our deposits, as will be seen from the examples which follow:

Hull.

At the well known Hull mines the magnetite occurs in crystalline limestone containing graphite, mica, and, more rarely, pyroxene.

Big ore-bed.

At Blairton in Belmont (the big ore-bed) the ore is interstratified with diabase, greenish epidotic and chloritic rocks, and crystalline limestone.

Seymour ore-bed.

At the Seymour ore-bed in Madoc the ore is underlaid by a thin band of soft mica-schist, and overlaid by reddish-grey, highly feldspathic rocks, in places porphyritic, and occasionally passing into syenite or syenitic gneiss. On the run of the bed to the eastward also, dark grey hornblendic rocks occupy the surface at times, as well as the feldspathic rocks just alluded to. Daubrée mentions the occurrence of a petro-siliceous rock at Dannemora which would appear to resemble somewhat the feldspathic rock near the Seymour ore-bed. It is known to the miners as *hälleflinta*, and is here and there porphyritic. (Ann. des Mines [4], iv. p. 223.)

Chaffey mine.

At the Chaffey mine, in South Crosby, the ore occurs in coarsely crystalline gneiss, containing both mica and hornblende. The gneiss adjoins a band of crystalline limestone.

Bedford.

On the west half of lot six, in the third concession of Bedford, the country rock is of exceedingly varied character. Among my specimens there is one consisting of an aggregate of black hornblende and greenish white feldspar; another consisting almost entirely of green translucent crystalline pyroxene; others are made up of similar green pyroxene, together with a little black hornblende, grains of magnetite, and in some instances a considerable proportion of calcite. Though the ore is more directly associated with these hornblendic and pyroxenic rocks, it is removed but a very short distance from a band of white crystalline limestone.

Bristol.

During the winter of 1872–73 several openings were made in deposits of magnetic ore on lots twenty-one and twenty-two of the second range of Bristol, Pontiac county, Quebec. The ore here forms a series of beds,

interstratified with reddish syenitic gneiss and glistening micaceous and hornblendic schists. The thickness of what appeared to be the most important and the uppermost bed could not be ascertained at the time of my visit in July last, as the opening upon it was nearly full of water; judging, however, from the quantity of ore taken out, the thickness must be considerable. Besides this bed, three others had been exposed by stripping; one of them was two feet thick, another only a few inches, but underlaid by occasional small lenticular patches of ore, while the fourth appeared to be about nine or ten feet thick, so far as the small amount of work done enabled one to judge. The micaceous and hornblendic schists in which the last mentioned bed occurs strike approximately east and west, dipping northward at an angle of only 35°. The general strike of the rocks as observed in the country for several miles east of the mines varied between E. and W. and E. 30° N., the angle of dip being usually high.

In the Report of Progress for 1872-73, p. 131, Mr. McOuat mentions the occurrence of magnetite interstratified with quartzite on the eighth portage of the Quinze. The ore forms "layers from the thickness of paper to about an inch, and is interlaminated with similar layers of whitish-grey and dull red, fine-grained quartzite. The iron ore constitutes probably from a fourth to a third of the whole, and, as the thickness of the whole band is about thirty feet, the total thicknes of the layers of iron would probably not be less than eight feet." Some of the Michigan ores occur in an analogous manner, and are, I believe, considered to be of Huronian age. Examples of a similar mode of occurrence are also to be found in Scandinavia. On the third lot of the fifth range of Elzevir magnetic ore is said by Mr. Macfarlane to occur in a talcose or steatitic rock.

The "Quinze."

Elzevir.

In speaking of the Foley mine, on page 194, I have incidently referred to the ore occurring in diorite. This rock forms extensive beds in the Laurentian as well as in the Huronian series. I say beds, although in many places it is quite impossible to distinguish the rock from diorites of igneous origin. It, however, appears in general to follow the sinuosities of the beds on either side of it, and is sometimes seen to graduate into hornblendic and micaceous schists. Many of the so-called Laurentian granites though locally shewing no parallelism in the arrangement of the constituent minerals, in like manner pass gradually into unmistakable gneisses.

Diorite.

The term diorite strictly speaking belongs to an igneous rock, and there seems to be no good name for a similar aggregate of sedimentary origin. Such an aggregate is sometimes called "hornblende-rock;" but this is certainly an erroneous name for a rock which is at times half made up of feldspar. Hornblende rock, strictly speaking, consists

mainly of hornblende; but according to Zirkel, by the addition of oligoclase, it passes now and then into diorite.* Cotta also says that the addition of feldspar to hornblende rock causes a transition into diorite. In using the term diorite in this way we make the name depend upon the mineral constituents of the rock, ignoring altogether the origin. What is needed is a term bearing the same relation to diorite that gneiss bears to granite.

Distinctive name needed for diorites of sedimentary origin.

At many places in Hastings and Addington counties, and elsewhere in Ontario, fine-grained diorites occur; those, however, which are associated with magnetic iron ore in the townships of Bathurst and South Sherbrooke are generally coarse-grained. The latter, in addition to black or dark green hornblende, and white, greyish or greenish feldspar, often contain scales of dark brown mica, grains of magnetic iron ore, and small quantities of quartz.†

Analysis of feldspar.

The feldspar was as carefully separated as possible from a specimen of the coarsely crystalline variety occurring at the Fournier mine. It was white to pale grey in colour, and in places shewed the striations character istic of triclinic feldspars. The specific gravity was 2.63–2.64 and hardness about 6. Before the blowpipe it fused at about 4 to a white enamel. An analysis gave the following results:

Silica	58.58
Alumina	24.78
Peroxide of iron	traces
Lime	4.84
Magnesia	0.20
Soda	6.63
Potash	2.15
Water	1.85
	99.03

It may accordingly be referred to the species oligoclase, although in some r-spects resembling andesite. The latter species, however, so far as I am aware, has not been noticed as a constituent of diorite. Besides the dark green hornblende associated with it, there were tolerably abundant scales of dark brown mica, and more rarely grains of quartz.

The examples given suffice to illustrate the variable character of the rocks containing deposits of magnetite in our old crystalline series. It should be remarked here that, while it is exceptional to find such deposits

* Lehrbuch der Petrographie, Band I. S. 304

† Gesner in his "Third Report on the Geological Survey of New Brunswick" mentions the occurrence of magnetic ore near Bull Moose Hill in the Parish of Springfield, in rocks which, judging from his description, appear to be somewhat similar to the coarse dioritic rocks of Bathurst and South Sherbooke, although he speaks of them as syenite.

in limestone, they very frequently occur near the junction of other rocks with the limestone. This fact should always be kept in mind in tracing or searching for magnetites, as the limestone bands are continuous and constant in character for long distances. **Proximity of magnetites to limestone.**

The minerals associated with our magnetic ores form a subject of study not only of scientific interest but also of economic importance, inasmuch as the quality of the iron produced often depends largely upon their presence with or absence from the ores, as the case may be. In Norway and Sweden a great many minerals have been detected, associated with the magnetites, which have not been observed in ours; they may, however, be found when the mines have been more fully developed. **Mineral associations of magnetite.**

The following is a list of the minerals collected last July and associated with the magnetites of this division (Laurentian and Huronian):

Apatite.	Limonite.
Calcite.	Malachite.
Chalcopyrite.	Mica, (probably Muscovite and Phlogopite).
Chlorite.	Pyrite.
Epidote.	Pyroxene.
Feldspar.—Orthoclase and Oligoclase. (see p. 198)	Pyrrhotite.
Fluor-spar	Quartz.
Garnet.	Serpentine.
Graphite.	Siderite.
Hematite.	Talc.
Hornblende (several varieties.)	Uran-ochre.
Ilmenite.	

Apatite.—This mineral occurs in a granular condition, as well as crystallized, associated with the magnetite, at the Foley mine, and also on the adjoining property (Bathurst, lot eight, range nine). At the Foley mine well formed crystals of apatite are sometimes found scattered here and there among the large octahedral crystals of magnetite. Apatite is of course an unwelcome associate, for when the ores are smelted the phosphorus passes into the iron, rendering it *cold-short*. Fortunately the magnetites of this group are in general very free from phosphates. **General freedom from phosphates.**

Calcite.—This is a very frequent associate of magnetite. Sometimes it is well crystallized, at others it occurs in large cleavable masses, while in some cases it is granular At the Forsyth mine (Hull) crevices in the ore often contain small but perfect crystals, both in the form of hexagonal prisms and in scalenohedra. Small rhombohedral crystals were also observed associated with the titaniferous magnetite at the Yankee or Mathew's mine in South Crosby. Large cleavable masses of white and pink calcite are associated with the magnetite at several localities in Bathurst, and granular calcite at some of the openings in Marmora. Limestones, we have already seen, are sometimes the country rock and sometimes interstratified with beds of magnetite. Calcite in limited quantity cannot be regarded as an injurious accompaniment of iron ores,

as, if not present, it has to be added, in the form of limestone, to form a slag in the smelting process.

Copper ores not common with magnetite.

Chalcopyrite.—Ores of copper seem to be rarely associated with our magnetites. Copper pyrites, however, is said to accompany the ore at the marsh ore-bed. It also occurs at the opening on the same lot referred to on page 194, and on the seventh lot of the second range of Escott. Small quantities of copper pyrites, partially converted into malachite, were observed in a vein cutting the magnetite of the Seymour ore-bed. The vein was composed mainly of quartz, actinolite, and calcite. The general absence of copper ores from our deposits of magnetite is a point in their favour, as it is well known that copper produces *red-shortness* in iron.

Chlorite at Dannemora mines.

Chlorite.—A green mineral occurring among other places at the Hull Chaffey, and Yankee mines, probably belongs to this species. It is sometimes disseminated through the ore, and sometimes, together with calcite, forms thin veins, or covers the walls of joints. Chlorite occurs in an analogous manner at the celebrated Dannemora mines in Sweden, and Daubrée referring to this fact, says :* "The magnetite is there intimately mingled with chlorite, more rarely with calcite ; the ore, of a dull colour and fine grain, is traversed in every direction by fissures which divide it into little polyhedra. The walls of separation of these polyhedra are planes, and usually clothed with a brilliant coating of chlorite which sometimes also forms little veins."

Epidote.—A green mineral associated with the magnetite of the big ore-bed at Blairton has been referred by Dr. Hunt to this species. It is frequently accompanied by small brilliant crystals of pyrites.

Feldspar.—Examples have already been given of the occurrence of magnetite in gneiss. In such cases the magnetite is often more or less mingled with the orthoclase and other constituents of the gneiss, and places may be observed where there is a gradation of the gneiss into a bed of magnetite by the addition and gradual increase in quantity of the latter mineral. A feldspar from the Fournier mine having the characters of oligoclase has been described on page 198. Oligoclase would form a better gangue-stone for an iron ore than orthoclase, for, being more basic, it would require the addition of smaller quantities of lime in order to form a slag.

Oligoclase as a gangue-stone.

Fluor-spar.—This species was observed as an associate of magnetite in one locality only—on lot six, range eight, of Marmora. A specimen before me is of a pale sea-green colour, but somewhat stained with peroxide of iron. It forms a mass of several cubic inches, embedded in magnetite, pyrites, and calcite. The presence of fluor-spar with iron ores would in many cases be advantageous

*Ann. des Mines, [4] iv., p. 222.

Garnet.—A reddish-brown variety of this mineral, approaching cinnamon-stone in colour, and associated with several other minerals in smaller quantity, forms the gangue-stone of what is perhaps a *vein* of magnetite on lot three, range five of Grenville. In places the gangue-stone is compact, but more frequently cavernous, the cavities being lined with beautiful dodecahedral crystals of garnet. Occasionally also, delicate rhombic prisms, apparently of hornblende, shoot out from the sides of these cavities. Beautiful crystals of garnet.

Garnet is frequently associated with magnetic iron ore in other parts of the world, as for example at Schmiedeberg, where, according to Cotta, it occurs in brownish-red or red trapezohedral crystals with striated planes.

Graphite.—This species, as repeatedly noticed in the Reports of the Geological Survey, occurs in the form of scales disseminated through much of the magnetite at the Hull mines. According to Daubrée it is also associated with some of the Swedish magnetites.

Hematite.—At some of the mines, more especially at Hull, Blairton, and Bristol, hematite occurs associated with the magnetite. Sometimes its presence is manifested by the red or reddish colour of the ore, as in the case of the so-called "red-ore" at Hull; at other times, however, the ore is black or greyish-black, but is shewn to consist in part of hematite by yielding a decidely red powder to the drill. In the latter case the hematite is probably present in the crystalline condition, while in the former it is earthy. A specimen of the Hull magnetite collected last summer contains little veins of red hematite crossing it in different directions, and others of calcite, of quartz and of pyrites; graphite and brilliant black hornblende are also disseminated through the magnetite, and a mass of steatite forms one wall of a little quartz vein. "Red ore."

Hornblende.—This is one of the most frequent of all the mineral associates of magnetite, and occurs in several varieties. In Bathurst and South Sherbrooke, where the iron ores occur in the coarsely crystalline diorites already described, they are often associated with cleavable masses of beautiful black or dark green hornblende. Good examples of this variety are to be found on the McVeigh lot (Bathurst lot 11, range 8), also at the Foley and Fournier mines. At the Hull mines black hornblende is often present with the magnetite, but not in large cleavable masses like those just referred to; and at the Bygrove mine in South Sherbrooke well-formed crystals are found. Hornblende a frequent associate of magnetite.

The following is an analysis of a specimen from the McVeigh lot in Bathurst: Analysis of hornblende.

Silica	40.02	
Alumina	15.55	
Peroxide of iron	3.44	Metallic iron 8.69
Protoxide of iron	8.60	
Lime	12.21	
Magnesia	14.37	
Potash	2.13	

Soda	2.40
Loss on ignition*	1.81
	100.53

Pargasite of Finland.

In composition this comes very near the so-called Pargasite from Pargas, in Finland, an analysis of which gave Rammelsberg the following results (Pogg. CIII, 444):

Silica	41.26	
Alumina	11.92	
Peroxide of iron	4.83	Metallic iron, 11.10.
Protoxide of iron	9.92	
Protoxide of manganese	trace.	
Lime	11.95	
Magnesia	13.49	
Potash	2.70	
Soda	1.44	
Water	0.52	
Fluorine	1.70	
	99.73	

The presence of ferruginous hornblendes advantageous.

The presence of these ferruginous hornblendes with magnetite, in limited quantity, is rather an advantage than otherwise, unless the ores have to be transported for long distances; for, besides a certain proportion of iron, they contain essential constituents for the formation of slags.

Actinolite.

The variety of hornblende known as actinolite forms the chief mineral associate of the finely granular magnetite of the Seymour ore-bed. It occurs in scattered radiating bunches and also uniformly disseminated through the ore. A little vein cutting the magnetite at this locality, and already spoken of as containing a small quantity of copper pyrites, was found to be mainly made up of quartz, calcite and actinolite, besides small grains of magnetite. The insoluble residue of a sample of ore from the Seymour bed was found by Dr. Hunt † to consist of magnesia 17.15, lime 11.01, protoxide of iron 11.95, silica, by difference, 59.89—this being the composition of actinolite. According to Professor Chapman actinolite is also an associate of the magnetite on lot twenty, range one, of Snowdon, Peterboro county. Occasional radiating masses of a bright green mineral at the Fournier mine, also, probably belong to this variety of hornblende.

According to Bauerman, ores accompanied by such minerals as pyroxene, hornblende, garnet, idocrase and chlorite are called in Sweden "*self-gaejende, i.e.*, self-going or self-fluxing."

Self-fluxing ores.

Ilmenite.—Many of the magnetic ores of this group are known to be titaniferous, and it is probable that in some cases at least, the titanium is present in ilmenite which is mixed with the magnetite, and is not really a

Titanium.

* Probably fluorine in part.

† Report of Progress 1866-69, p 259.

constituent of the latter. This was found by Dr. Hunt to be the case with certain ores from the Quebec group in the Eastern Townships; and in some of the Laurentian ores from the Adirondacks the two minerals are said to be distinguishable by the eye, owing to a slight difference in colour and lustre.

Limonite.—Near the surface of deposits of magnetite, a partial alteration to hydrated peroxide of iron may often be observed. This appears to be more frequently the case when the deposits occur in schistose strata like the mica schist at the Bristol mine. The enclosing rocks, also, frequently present a rusty appearance. In some cases the origin of the limonite is probably the decomposition of pyrites associated with the magnetite rather than an alteration of the magnetite itself. **Magnetite more liable to alteration when in schistose strata.**

Malachite.—This was observed in only one instance, at the Seymour ore-bed, and then only in sufficient quantity to say that it did exist.

Mica.—The mica found associated with the magnetites of this group probably belongs to several species, which, however, have not been determined. In general it is dark brown or brownish-black in colour; but occasionally of lighter colours. At the Bristol mine much of the mica is of a pale silvery-grey colour. There is no more frequent associate of magnetite.

Pyrite or Pyrites.—The occurrence of this mineral is more frequent than desirable. Occasionally it is well crystallized; sometimes masses of considerable size are found here and there embedded in the magnetite; but more frequently it occurs in minute grains scattered through the ore, or in little strings or veins. At the Bristol mine it occurs in such quantity as to greatly lessen the value of the ore; at Hull, the ore from the Baldwin mine seems to be pretty free from it, but it may be noticed in much of the ore at the Forsyth mine, both in disseminated grains and little veins; at the Foley mine, as well as at the openings on the adjoining properties, the ore seen was very free from it; at the Fournier mine it occurs in small quantity, but generally associated with the hornblende rather than with the magnetite; at the Yankee or Mathews' mine it is almost impossible to find a specimen of the ore not shewing pyrites either in thin strings or disseminated grains. It also is common in the ore at the Chaffey mine. In what was supposed to be an average sample of the ore from the latter locality Dr. Hunt found 1.52 per cent. of sulphur, which, calculated as pyrites, gives 2.85 per cent. **Occurrence of pyrites.**

At the Christie's Lake mine a good deal was observed, not, however, generally disseminated through the ore, but in veins which would be readily separable. It sometimes occurs at this locality in well-defined cubes. The magnetite of the Seymour ore-bed is unusually free from pyrites, and is undoubtedly one of the finest ores in the country. The ore of the marsh ore-bed, and other openings near it, contains large quantities of **Fine magnetite.**

pyrites. The big ore-bed in Belmont in portions of its thickness contains a good deal, while other portions contain but little; curious concretions occur at this mine, consisting of alternate layers of pyrites and hematite. Ores containing much pyrites should always be roasted before smelting, by which means much of the sulphur is got rid of. The effect of sulphur upon iron, as is well known, is to make it *red-short*, or brittle when hot.

Advantage of roasting.

Pyroxene.—This is a frequent associate of the magnetites of this group, though by no means so common as hornblende. At the Hull mines the limestone adjoining the magnetite contains crytals of pyroxene some of which are green, and others greenish-yellow and transparent; these, like the crystals of apatite in many Laurentian limestones, are often curiously rounded. One of the rocks associated with the magnetite of the big ore-bed is described in the Geology of Canada as a diabase, and, therefore, contains pyroxene as one of its constituents. At this locality, also, a pale green coccolite is occasionally mixed with the magnetite. On lot six, concession three, of Bedford, there occurs with the magnetite a rock which in some places is almost entirely made up of a green, crystalline, translucent pyroxene with a specific gravity of 3.30, and in others contains, in addition to the pyroxene, grains of magnetite, as well as brilliant black hornblende and white calcite.

Rounded crystals of pyroxene.

Pyrrhotine.—This mineral occurs associated with the magnetite of the marsh ore-bed, and its presence is, of course, objectionable. It was not observed in other localities.

Quartz.—Of this species little need be said. It frequently accompanies magnetite in the form of disseminated grains, or in little veins. In some localities, as already mentioned, it constitutes the rock with which the magnetite is interstratified. When present it requires in smelting the addition of lime or other basic substances in larger quantities than would otherwise be necessary.

Good examples of the occurrence of serpentine.

Serpentine.—The best examples of the occurrence of this mineral are to be found at the big ore-bed, Belmont, where it is found massive, foliated and fibrous. Some of the massive variety is of a dark green colour and some yellowish-green and translucent. The latter passes into foliated and fibrous varieties, marmolite and chrysotile, which are pale green or greenish white. The fibrous serpentine is sometimes mistaken for asbestus, a variety of hornblende.

Siderite or Spathic Iron. This mineral was observed associated with magnetite in only one instance; namely, on lot six range eight of Marmora. It was well crystallized, but in small quantity, and accompanied by a number of other minerals enumerated on page 194. The siderite is probably of more recent age than the magnetite, and formed from the alteration of the latter.

Siderite from alteration of magnetite.

Talc.—Among the specimens collected at Hull and also at the Sey-

mour ore-bed, are several shewing small quantities apparently of steatite, the earthy variety of talc, associated with magnetite. In the latter case it appears to be the result of the alteration of actinolite. The occurrence of magnetic iron ore in a "talcose or steatitic substance" on the third lot of the fifth range of Elzevir has already been referred to.

Actinolite altered to steatite.

Uran-ochre.—The occurrence of this mineral at the Seymour ore-bed is mentioned by Dr. Hunt in the Geology of Canada (1863). It forms a lemon-yellow coating or crust upon the walls of fissures in the magnetite. Quite recently Professor Chapman has noticed its occurrence with magnetite on lot twenty, range one, of Snowdon township, Peterboro' county.

Uran-ochre recently observed by Professor Chapman.

MODE OF OCCURRENCE AND MINERAL ASSOCIATIONS OF MAGNETITES MORE RECENT THAN THE HURONIAN.

The metamorphic rocks of the Eastern Townships, which are regarded by Sir W. E. Logan as of Lower Silurian age, occasionally contain deposits of magnetic iron ore. Few of them, however, appear to be of much economic importance, and none, so far as I can learn, are being worked at present. As yet I have had no opportunity of visiting them.

No deposits being worked in the Eastern Townships.

Some of the dolomitic and chloritic schists of this region contain considerable quantities of magnetite in disseminated octahedral crystals. In a specimen from the ninth lot of the ninth range of Sutton, consisting of dolomite and magnetite, Dr. Hunt found the latter mineral to equal fifty-six per cent. of the mass. Minute crystals of magnetite were also found to constitute more than half the weight of a chloritic rock from the second lot of the fourteenth range of Bolton (Geol. of Can., 1863, p. 677).

Magnetite in dolomitic, chloritic and talcose rocks.

In 1872, also, specimens of chloritic and talcose schists, containing disseminated octahedral crystals of magnetite, were brought by Mr. W. McOuat, of the Geological Survey, from Lake Opasatika, which closely resemble some of those from the Eastern Townships, and are possibly of the same age.

According to Dana chloritic slates with octahedral crystals of magnetite occur in Corsica, and also at Fahlun in Sweden.

In the Geology of Canada, 1863, page 677, large loose fragments of magnetic iron ore are spoken of as occurring near a band of serpentine on the second lot of the tenth range of Leeds (Megantic). Since then the ore has been discovered *in situ* on the seventh lot of the fifth range. Mr. Charles Robb, who visited the locality last spring, tells me that the strata had been exposed by stripping for a distance of forty yards in the direction of the strike, and sixteen yards across it. In the latter distance three tolerably regular beds of ore were seen, respectively six, four, and three feet thick, and all dipping to the north-west at an angle of 50°. The beds are separated by bands of chloritic slate containing quartz and calc-spar.

Magnetite of Leeds, Megantic.

The ore is a fine-grained magnetite, more or less mixed with micaceous iron ore, and some specimens exhibiting polarity in a marked manner. A specimen of magnetite from the adjoining township of Inverness, strongly resembling that from Leeds, was sent a short time ago to the Geological Survey office for examination, and its analysis will be given further on. Possibly it is from a continuation of the deposit occurring in Leeds.

Inverness.

In the Seigniory of St. Francis, Beauce, a bed of granular iron ore, forty-five feet wide, occurs in serpentine. It was found by Dr. Hunt to consist of a mixture of about two-thirds magnetite and one-third ilmenite. (Geology of Canada, 1863, p.501)

Mixture of magnetite and ilmenite.

In the Upper Silurian slates and quartzites of Nova Scotia magnetite occurs in veins associated with specular or micaceous ores at Londonderry, and also near the East River, Pictou county. The proportion of magnetite, however, is usually small. A mixture of this kind from the East River is locally known as "specular magnetic."

"Specular magnetic."

While in Truro, in September last, specimens of magnetite were given me which were said to be from a bed six feet thick and about twelve miles west of Truro, but whether the deposit is really one of importance I cannot say.

Deposit near Truro, N. S.

The fossiliferous hematites of the Devonian slates on the south side of Annapolis Valley have in many cases been more or less completely altered to magnetite, which still, however, holds numerous fossils of Lower Devonian age. This metamorphism, according to Dr. Dawson,* has taken place chiefly at Moose River, to the south of the great mass of granite in Annapolis county. A short time since, however, a massive, fine-grained magnetite resembling some of the Laurentian ores, was sent to the laboratory of the Geological Survey for examination, and said to be from Nictaux River. It held no fossils whatever, but, like the fossiliferous ores of the district contained a large quantity of phosphorus. Probably it was taken from near the granite, which would account for its highly metamorphosed condition. Magnetic iron ore of Devonian age also occurs on Deer Island in Passamaquoddy Bay, New Brunswick.

Magnetite of Devonian age.

According to Mr. Richardson, deposits of magnetite occur on Texada Island, British Columbia, associated with dioritic rocks and limestones holding Devonian fossils; but little is as yet known of their extent.†

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* See Acadian Geology, pp. 498-501.

† Mr. Richardson has placed in my hands several specimens of magnetite (age unknown) given to him by gentlemen in British Columbia. The specimens are accompanied by the following memorandum:—

No. 1.—From 50 yards back from the Cariboo and Yale waggon road, up a ravine half a mile below Nicoameen, Lytton District. Bed 8 feet thick. Specimen given by Joseph William McKay, Esq., Factor H. B. Co. Service, Victoria.

No. 2.—Ore from one mile up the river at the head of Knight's Inlet. Given by Alexander Donaldson, Esq., of Victoria.

No. 3.—From Mountain, south side of Lake Howse, about 10 miles from Hope, Hope and Similkameen trail. Given by J. W. McKay, Esq.

Magnetite is wanting in rocks of Carboniferous age; but passing on to the Trias we find that it occurs in veins in the great ridge of trap bordering the south-eastern side of the Bay of Fundy. These veins can scarcely be regarded as of economic importance, although a few attempts to work them have been made. Thus at North Mountain, in Annapolis county, two miles from Middletown Station, on a farm owned by Mr. John Dodge, there is a vein in the trap, said to be from six to nine inches thick, from which about one hundred and fifty tons of ore were taken in 1871 and carried to the furnace at Londonderry. Much of it is well crystallised in dodecahedra and combinations of the octahedron and dodecahedron. Some of the specimens lying near the furnace at Londonderry were associated with calcite, and others with colourless and amethystine quartz.

Absence of magnetite from Carboniferous rocks.

Veins in Triassic trap.

Many of our old crystalline rocks contain disseminated grains and crystals of magnetite and ilmenite, which, on the disintegration of the rocks, are gathered together and form deposits of what is known as "iron sand." This iron sand is always more or less mixed with siliceous sand, so that artificial processes of concentration have generally to be employed before it can be utilized for the manufacture of iron. Grains of garnet are also frequently present, but generally in small quantity.

Iron sand.

The most important deposits of iron sand in Canada are those along the north coast of the Gulf of St. Lawrence, at Moisie, Bersimis, Mingan, &c., &c.; but they are also found in places along the shores of the great lakes of the interior. As regards the age of the gulf deposits, some are modern, indeed are being formed at the present moment, but others belong to the Post-pliocene age, when the elevation of the land was much less than it is at present. In some places they are found as high as 100 and even 200 feet above tide-level.*

* Full information concerning the iron sands of the Gulf may be found in Dr. Hunt's Report in the volume published by the Geological Survey for 1866–69.

COMPOSITION OF MAGNETIC ORES.

Analyses of samples of the magnetic ores from a number of the more important deposits in the country have already been published in the Reports of the Geological Survey, and some of them will be repeated here for the sake of comparison. A few, however, which have been recently made will be given first.

Bristol ore, a mixture of magnetite and hematite.

Bristol.—The deposits occurring on the twenty-first and twenty-second lots of the second range of Bristol have been described on pages 196 and 197. The ore, though generally called magnetic iron ore, is really a mixture of crystalline magnetite and hematite, with a streak ranging in colour from reddish to black. The specimen selected for analysis, and regarded as representing the average of what had been taken from the largest excavation up to July last, was rather finely granular, of a dark steel-grey colour, and readily attracted by the magnet. The streak varied from reddish-brown to black in places. Scattered here and there through the mass were nests of pyrites, some of them nearly a quarter of an inch in diameter, and with the glass disseminated grains of quartz and calcite could be seen. The specific gravity was 4.32, and the results of an analysis as follows:

Analysis of Bristol ore.

Peroxide of iron	65.44
Protoxide of iron	14.50
Bisulphide of iron	2.74
Protoxide of Manganese	0.11
Alumina	0.60
Lime	3.90
Magnesia	0.45
Silica	11.45
Carbonic acid	1.64
Phosphoric acid	traces
Titanic acid	none
Water	0.14
	100.97

Iron as peroxide	45.81
Iron as protoxide	11.28
Iron as bisulphide	1.28
Total metallic iron	58.37
Sulphur	1.46

Combining a sufficient quantity of the peroxide of iron with the protoxide to form magnetic oxide, we find the ore to be a mixture of magnetite and hematite, in the proportion of 46.72 of the former to 33.22 of the latter (1.40 : 1).

Leeds.—On page 205 a short description has been given of the deposit of ore occurring on lot seven, range five of the township of Leeds (Megantic). The schistose variety consists of a mixture of micaceous iron ore and magnetite, the latter often in minute octahedral crystals. Mr. Hoffmann has analysed a specimen of this kind, containing a large proportion of the micaceous ore, but still strongly magnetic. The colour was iron-black or in places reddish, and the streak black with a reddish tinge. Through the ore were disseminated small nodules of a mineral with a glassy lustre, apparently orthoclase, with which mineral they were found to agree in hardness and fusibility. The specific gravity was 5.041, and an analysis gave: **Analysis of Leeds ore.**

Peroxide of iron	80.758
Protoxide of iron	13 588
Protoxide of Manganese	0.056
Silica (in solution)	0.012
Alumina	0.713
Lime	1.298
Magnesia	0.454
Phosphoric acid	0.471
Sulphuric acid	0.095
Titanic acid	none
Hygroscopic water	0.049
Combined water	0.167
Organic matter	0.041
Insoluble matter	2.748
	100.450
Iron as peroxide	56.531
Iron as protoxide	10.568
Total metallic iron	67.099
Phosphorus	0.206
Sulphur	0.038

The insoluble residue was also analysed and found to contain:

Silica	2.420
Alumina	0.270
Lime	0.014
Magnesia	0.012
Potash	0.076
	2.792

The ore appears to vary considerably in the quantity of phosphorus which it contains. Thus, a specimen of the massive magnetite containing 66.33 per cent. of iron gave me 0.335 per cent. of phosphorus. Equal quantities of seven specimens also, broken from loose masses on the surface at intervals along a line of three-quarters of a mile, were mixed together, and the mixture found to contain only 0.025 per cent. The average quantity of phosphorus deduced from the three determinations **Variable proportions of phosphorus.**

just given is 0·188 per cent. Another specimen of the massive variety, examined only for iron, gave 64.78 per cent.

Analysis of Inverness ore.

Inverness.—A specimen of ore from this township was sent a short time ago to the museum of the Geological Survey by Mr. Edward Major of Montreal. It was a finely-granular magnetite of an iron-black colour and with a specific gravity of 4.77. An analysis gave :

Magnetic oxide of iron	90.360
Protoxide of manganese	0.175
Lime	3.040
Magnesia	traces
Phosphoric acid	0.443
Sulphur	0.005
Insoluble residue	6.500
	100.523
Metallic iron	65.433
Phosphorus	0.193

It contained no titanic acid whatever. Whether the specimen is from a deposit of importance is not yet known.

Analysis of Nictaux ore.

Nictaux.—A partial analysis has been made of the specimen of Devonian magnetite mentioned on page 206. It was very fine-grained and tough, breaking with a sub-conchoidal fracture. Calculating the iron as magnetic oxide it contained :

Magnetic oxide of iron	69.17
Phosphoric acid	1.82
Sulphur	0.05
Insoluble matter	18.94
Metallic iron	50.09
Phosphorus	0.79

Analysis of ore from Christie's Lake mine.

Christie's Lake Mine.—A specimen of compact magnetite from this mine (lot 18, range 3, South Sherbrooke) of an iron-black colour and metallic lustre was found to contain :

Magnetic oxide of iron	90.61
Titanic acid	2.83
Phosphoric acid	0.05
Metallic iron	65.62

Other constituents were not determined, the ore having been examined simply with the view of ascertaining whether it contained phosphoric or titanic acids.

TABLE OF ANALYSES OF MAGNETITES.

Constituents.	I.	II.	III.	IV.	V.	VI.
Peroxide of iron...... } Protoxide of iron..... }	73.90	93.82	66.20	69.77	90.14	72.80
			17.78			
Oxide of manganese...	none.	0.12	traces.	....	traces.	....
Alumina	0.61	0.79	....	5 65	1.33	....
Lime	none.	0.45	1·85	....	0.82	1.69
Magnesia	1.88	0.94	0.18	4.50	0.84	6 86
Phosphorus.	0.027	0.08	0.015	0.085	0.007	0.035
Sulphur	0.085	0.11	0.28	1.52	0.12	0.027
Carbonic acid............	....	....	1.17	....	....	1.50
Silica	20.27	3.75	11.11	7.10	....	....
Titanic acid...............	none.	....	none.	9.80	1.03	....
Graphite	....	....	0.71	....	....	....
Water.....	3.27	....	....	2.45	....	3.50
Insoluble matter	....	....	....	....	5.25	14.73
	100.042	100.06	99.295	100.875	99.537	101.142
Metallic iron..............	53.51	67.94	60.17	50.52	65.27	52.72

Constituents.	VII.	VIII.	IX.	X.	XI.	XII.
Peroxide of iron...... } Protoxide of iron..... }	89.22	58.35	59.39	80.76	65.44 }	90.36
		24.87	26.93	13.59	14.50 }	
Oxide of manganese...	none.	0.13	traces.	0.06	0.11	0.17
Alumina	....	0.42	0.67	0.71	0.60	....
Lime	none.	1.43	0.33	1.30	3.90	3.04
Magnesia	....	2.56	0.82	0.45	0.45	traces.
Phosphorus...............	0.012	0.07	traces.	0.21	traces.	0.19
Sulphur.....................	0.073	0.04	0.07	0.04	2.74†	0.005
Carbonic acid............	....	....	....	....	1.64	....
Silica	....	11.17	....	0.01	11.45	....
Titanic acid...............	....	0.73	3.23	none.	none.	none.
Water	....	....	....	0.22	0.14	....
Organic matter...........		....	....	0.04	....	....
Insoluble matter.........	10.42	....	8.38*	2.75	....	6.50
	99.725	99.77	99.82	100.14	100.97	100.265
Metallic iron..............	64.61	60.19	62.52	67.10	58.37	65.43

The above table is compiled from different sources. With the exception of number II, the first seven analyses are from the Report of Progress for 1866–69, and are by Dr. T. Sterry Hunt. II is by Professor Chandler, of the Columbia School of Mines, New York, and VIII and IX by Professor Chapman, of Toronto. The three last are from the preceding pages, but are repeated to facilitate comparison. The localities from which the specimens were taken are as follows: Analysts.

I.—Hull. "Black ore."
II.— " " " A picked specimen.
III.— " The so-called red ore, a mixture of magnetite and hematite.
IV.—Chaffey mine, South Crosby.
V.—North Crosby; from a deposit on land belonging to Hon. George W. Allan, of Toronto.

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* Silica and insoluble rock matter.
† Bisulphide of iron.

VI.—Blairton mines, sand-pit bed, Belmont.
VII.—Seymour ore-bed, Madoc.
VIII.—Lot twenty, concession one, of Snowdon, Peterboro county. (Sp. gr. 4.22.)
IX.—Lot twenty-nine or thirty of the first concession of Bedford, Ont. (near Eagle Lake).
X.—Leeds, P.Q. See pp. 205 and 209.
XI.—Bristol, P.Q " 196 and 208.
XII.—Inverness, P.Q. " 206 and 210.

HEMATITE.

Varieties of hematite.

Under this name are included several varieties of iron ore consisting mainly of anhydrous peroxide of iron, the varieties depending upon texture rather than chemical composition. Specular and micaceous iron ore are terms applied to crystalline varieties with metallic lustre, the latter also having a foliated or micaceous structure. Earthy varieties, often containing clay, are known as red ochre, while intermediate between the highly crystalline and the ochreous ores comes red hematite. The latter term is sometimes used by iron smelters in the same general sense that hematite alone is, to indicate any ore consisting essentially of anhydrous peroxide of iron. As a rule, hematite is freer from impurities than magnetite ; it is not so easily reduced as hydrated oxides or carbonates, and is liable to produce grey rather than white iron, a fact of importance in connection with the manufacture of Bessemer pig.

Geological range of hematites.

Geologically our hematites have a wide range in time. They are found in the Laurentian, Huronian, Lower Silurian, Upper Silurian, Devonian, Carboniferous, and Trias. Red ochres of modern age are also occasionally met with. In the Laurentian, hematite is by no means as common as magnetite, and more frequently occurs in the form of red hematite than in the more highly crystalline varieties. The Canadian hematites of Laurentian and Huronian age cannot be regarded as forming a specially important group apart from those more recent, and accordingly the division given under magnetite will not be adopted here.

MODE OF OCCURRENCE AND MINERAL ASSOCIATIONS OF HEMATITE.

Beds and veins.

Hematite occurs in both beds and veins, the beds generally, though not always, being the more important deposits. Like magnetite it is not found solely in any one kind of rock, but often in rocks of most diverse characters. A few examples illustrative of this fact may be of interest. Beginning with the Laurentian, we find at the McNab mine near Arnprior a compact red hematite occuring in crystalline limestone. The bed is inclined at a high angle and has been worked to a depth of about eighty feet when it is said to have thinned out. At the Dalhousie mine, twelve miles from Perth, a compact red hematite, somewhat similar to the McNab ore, also occurs in limestone, although at one point in the workings a soft chloritic looking slate, with numerous

Hematite in limestone.

crystals of pyrites, seems to intervene between the ore and the underlying limestone. The limestone is highly crystalline; that underlying the main deposit being white and containing large quantities of tremolite, while that which overlies it is stained red with peroxide of iron. When the mine was opened up there appeared to be two beds cropping out in places at the surface with four or five feet of limestone between them. The uppermost and smaller of these was found to run out at few feet in depth, and to extend but a short distance in the direction of the strike. The larger deposit was in places as much as nine feet thick at the surface, and at a depth of eighty feet had an average thickness of four or five feet.

Among other examples of the occurrence of hematite in Laurentian limestone may be mentioned the thin vein of specular ore on lot two range four of Elzevir (Geol. of Can. 1866, p 101), and the finely-granular hematite of Iron Island, Lake Nipissing.

The specular ore of the Haycock location in Templeton and Hull, occurs in highly feldspathic gneiss, mostly of a reddish colour, though interstratified with occasional grey bands. The ore forms a series of apparently parallel beds, striking north-east and south-west and dipping to the north-west at an angle of about 50°. Some of what appeared at the time of my visit to be distinct beds may prove to be merely repetitions of the same one, but sufficient work had not been done to determine this. The thickness of those exposed varied from a few inches up to several feet.* Besides the beds occasional little veins of hematite were observed cutting the gneiss. So far as I am aware this is the only workable deposit of specular ore known in the Laurentian rocks of Canada. Hematite in gneiss.

According to Mr. Macfarlane a vein of earthy hematite associated with chlorite occurs in a fine-grained diorite near the iron furnaces at Marmora, and was worked many years ago (Geol. of Can., 1866, p. 102). Diorite.

No such important deposits as those of Michigan have yet been discovered in our so-called Huronian rocks. Some of those known, however, are very similar in their mode of occurrence, consisting for the most part of alternate layers of compact hematite or specular ore and quartzite or jasper, in dioritic and diabasic rocks. The deposits of Bachewahnung Bay and Gros Cap, Michipicoten, are well known examples. (See Geol. of Can., 1866, p. 130.) Huronian ores in dioritic and diabasic rocks.

According to Professor Bailey and Mr. Matthew, the Huronian strata of the eastern part of St. John county, New Brunswick, contain red hematite and specular iron ore. At West Beach, twelve miles east of the city

* In a recent letter Mr. R. H. Haycock states that one bed having a thickness of only two feet at the surface has, at a depth of fourteen feet, widened to fifteen feet.

of St. John, a bed of reddish-brown hematite occurs in the upper part of a mass of reddish-grey conglomerate; and two or three miles east of West Beach, near Black River, several beds of specular ore occur, associated with dioritic rocks and micaceous schists. One of these beds is said to have a thickness of twenty feet. The rocks at West Beach and Black River were, until a few years ago, considered to be of Devonian age. (Report, 1870–71, pp. 98 and 223).

Conglomerate.

Potsdam sandstones.

The Potsdam sandstones are sometimes impregnated with considerable quantities of peroxide of iron, and occasionally contain micaceous and specular ores. The quantity of these, however, has never been found sufficient for profitable working. In the metamorphic rocks of the Quebec group, on the other hand, workable deposits of hematite occasionally occur. Some of them have been described in the Geology of Canada under the name of specular schist or itabirite, and are there stated to consist of scales of micaceous iron ore, grains of quartz, and frequently also chlorite. They generally occur interstratified with chloritic slates or chloritic slates, argillites and dolomites. Besides these beds, veins of foliated specular ore with quartz are sometimes met with, but are not of economic importance. (See Geol. of Can., 1863, p. 678 et seq.)

Quebec group.

Specular schists in chloritic slates, argillites and dolomites.

Lower Silurian.

In the Lower Silurian rocks of New Brunswick, also, extensive deposits of hematite occur at Woodstock. They have been described by different writers, and among them by Professor Hind who says of them: * "These ores are vast sedimentary deposits many feet in thickness, interstratified with red and green argillites, or with calcareo-magnesian slates, of a red or green, or mottled red and green color. The ores vary in composition, being both red and black, the black is sometimes feebly magnetic, but it derives its color more from the presence of manganese than from the black magnetic oxide. The red ore is an impure hematite, containing, besides the peroxide of iron, some carbonate of the protoxide, and from one to six per cent. of manganese; it is often seamed with thin layers of graphite." The Woodstock ore, though generally described as hematite, may be a mixture of hematite and limonite, as all the published analyses indicate a considerable proportion of water.

Remarks by Professor Hind on the Woodstock ores.

Upper Silurian.

Rising in the geological scale to the Upper Silurian we find some exceedingly important deposits of hematite; but this, so far as known, only in the Province of Nova Scotia. As specular or rather micaceous iron ore, it is found in veins in the Cobequid Hills of Londonderry, and near the East River of Pictou County, that of the latter region being regarded by Dr. Dawson as the equivalent of the Londonderry ore. Earthy red ore in veins also occurs in large quantity near Londonderry, while beds of siliceous red hematite of enormous extent occur in Pictou County.

* Preliminary Report on the Geology of New Brunswick, together with a special Report on the Distribution of the "Quebec Group" in the Province. Fredricton, 1865.

At Londonderry the country rock consists of grey, blackish and olive slates, alternating with bands of grey quartzite, and overlaid by grey and brown sandstones and shales of Carboniferous age. The former are cut by irregular veins, which sometimes attain a thickness of many feet, and at others disappear altogether, or are represented by a network of small reticulating veins. These reticulating veins appear to be more common in the quartzite than in the slates. The materials constituting the veins consist of ankerite, spathic iron, earthy red ore, micaceous and specular iron ore, limonite and small quantities of several other minerals which will be noticed further on. The ankerite seems to have formed the largest part of the original material of the veins, and is the gangue-stone of the specular ore. By its decomposition, as well as that of the spathic ore, large quantities of limonite and earthy red ore have been produced.

Country rock at Londonderry.

Materials constituting veins.

Though specular ore is rarely absent from the Londonderry veins, being scattered through the ankerite, and sometimes also through the limonite and red ore, in little bunches and strings, the proportion is generally small. Near the west bank of Cook's Brook, however, a level was many years ago driven on the course of the main vein for a distance of one hundred and fifty yards. The vein is said to have been struck at about fifty yards from the mouth of the level, and to have had an average thickness of three or four feet, consisting of specular or micaceous ore with small quantities of red ore and ankerite. Much of the ore is readily attracted by the magnet, so that there must be also magnetic oxide present. At the time of my visit in September last the level was closed up, and all that could be seen was the ore which had been taken from it, and was piled at its mouth. The reason assigned for its not having been employed at the furnace was that it was too difficult to reduce, and it is easy to understand how persons accustomed to smelting limonite might at first experience difficulty in the treatment of specular ore.

Specular ore of Londonderry.

In Pictou County specular ore has been discovered in a number of localities, but the only one which has been shown to be of much economic importance is that a short distance west of the east branch of the East River, on area 100 of the government plan. Though I visited it last September, I can say little of it from personal observation, as the openings were at that time full of water. It was first described by the late Mr. Edward Hartley in the Report of the Geological Survey for 1866–69, and was subsequently reported upon, in 1872, by Mr. G. M. Dawson, Associate of the Royal School of Mines, London. From the report of the latter gentleman, kindly placed in my hands by Principal Dawson, I extract the following, as being the fullest and most recent information on the subject: "This ore (specular iron ore) occurs on the square mile marked 100 on the government plan. The country rock is a blackish slate with occasional beds of quartzite, and it is with one of the latter beds that the ore is most closely

Specular ore of Pictou County.

Extract from Mr. G. M. Dawson's report.

associated. The strata are in general undulating, and in places somewhat contorted, but preserve a pretty uniform southerly dip at an angle of from 60° to 70°.

"The ore deposit occurs as a true lode following very nearly the strike of the containing rocks, and, so far as our explorations have gone, appearing to be as nearly as possible vertical. It has been exposed by trenching and proved by small shafts from the eastern boundary of the area westward for a considerable distance, though as yet not quite across to the western line. Of its extension across the entire area, however, there can be no doubt from the indications, and the ore is known to occur on some of the other areas both east and west of this, though its value has not yet been proven by actual exposure of its thickness and quality.

"At the eastern boundary of area 100 the outcrop of the lode is exhibited in a trench and shows a thickness of twelve feet of ore, though with some thin leaves of intercalated slate. A short distance west of this is another costeaning trench in which the lode is shown to have a thickness of 5 feet 6 inches, of good and pure ore.

"About 900 feet westward from this, a shaft 18 feet deep has been sunk on the crop of the lode. At a short distance from the surface a horse of hard quartzite rock, more or less impregnated with ore, encroached on the southern side, but at the bottom this was passed through, and the ore found passing under and cutting it out.

"The lode was cross-cut at a depth of 13 ft., and the thickness found to be 10 ft., including, however, about a foot of slate. At the bottom of the shaft the lode was widening. From this shaft alone about 40 tons of good ore were extracted. In connection with the quartzite horse and wall a small quantity of iron pyrites was found in association with the ore.

"From this shaft westward 1,086 ft. on the course of the lode a second opening was made and carried down to a depth of about 13 ft. At this place the true lode was missed, and quartzite and hard slate impregnated with ore continued to the bottom. By subsequent trenching the lode was discovered to lie about 30 ft. south of the shaft, and it there exhibited a a very favorable appearance, and showed 20 ft. of good and very pure ore. The southern wall was not found, as the rock dipped away fast, and the water was troublesome.

"This deposit of micaceous and specular iron ore is situated on high ground, and the course of the lode is cut across in several places by deep brook vallies, which, though encumbered by drift, and presenting no good exposures of the deposit at present, will offer great advantages by allowing free drainage to a very considerable depth."

The ore of this locality, judging from what I saw upon the surface, resembles closely the micaceous ore of Londonderry.

"Red ores" of Londonderry.

The so-called "red ores" of Londonderry, mentioned on page 214 have

evidently been produced from the decomposition of spathic iron and ankerite, as they frequently exhibit the rhombohedral forms characteristic of these minerals, and this even when the iron is entirely converted into peroxide. They vary much in colour, and probably consist of varying mixtures of anhydrous and hydrous peroxide of iron. A specimen of a reddish-brown colour from the Peter Totten lot, apparently produced by the alteration of spathic ore holding little veins of calcite, was found to contain 69.86 per cent. of peroxide of iron and 5.74 of combined water.

On the west side of Cumberland Brook, a little over two and a half miles in a straight line west of the Londonderry furnace, an earthy red ore is being mined at present, and apparently exists in large quantity.

Siliceous hematite of Pictou County, N. S.

The siliceous bedded hematite, mentioned on page 214, occurs in rocks which are referred by Dr. Dawson to the Lower Helderberg (Ludlow of Great Britain) and regarded by him as more recent than those containing the specular ore of the region. They are coarser-grained and much more contorted and faulted, but, like them, consist of slates and quartzites, the former being of different shades of grey, greenish-grey and black, and the latter grey, brownish-grey, and red or reddish where ferruginous. Occasional calcareous bands holding fossils also occur. The ore consists of little siliceous grains enveloped with peroxide of iron. It is sometimes earthy but more frequently hard and compact, the latter kind often having a somewhat schistose or slaty structure. In portions of its course the bed holds fossils, while in others none can be detected.

Character of country rock.

Fossils.

Distribution of hematite in Pictou County.

The principal developements of this ore, so far as known, are near the east branch of the East River of Pictou County, and on the upper part of Sutherland's River, and apparently belong to two lines of outcrop of the same bed on opposite sides of an anticlinal. On the northern side of the anticlinal it has, according to Dr. Dawson, been traced completely across area 101 of the government plan, and it is thought that it will be found to continue across area 49 and to connect with exposures known on 48. Exploratory work undertaken under the direction of Mr. G. M. Dawson, in 1872, shewed the thickness of workable ore to range from 10 to over 20 feet. The surface thickness of the bed in several places where I measured it was from 27 to 30 feet, and this with a high angle of dip. All the ore observed on this side of the anticlinal was free from fossils.

On the south side of the anticlinal traces of the ore are found across the northern corner of area 102, and in the southern corner of 45 extensive exposures occur; the band then curves round, and passing through the eastern corner of area 46 enters 108, which it partly crosses, with a course a little east of south, or nearly at right angles to its course on 102. The only exposure on this side of the anticlinal which I visited was on area 45 (Blanchard's). Here the bed forms a ridge projecting several

feet above the general surface of the ground, and large quantities of ore could easily be obtained from it; but unfortunately much of it is very fossiliferous.

Going northward again we find the ore bed repeated on Sutherland's River, at a distance of between two and three miles from where it is exposed on area 101. It has here a southerly dip, and appears to occur at the northern side of a synclinal corresponding to the anticlinal referred to above. Of the extent or importance of this portion of the deposit little is as yet known.

Hematite of Upper Silurian age in Ontario.

In the Geology of Canada, p. 682, the occurrence of red hematite in Ontario, in rocks belonging to the Clinton formation, is mentioned. The deposits, however, are not known to be of any economic importance.

Devonian hematite.

According to Dr. Dawson, * the Devonian slates of Nictaux River, Nova Scotia, contain a bed of highly fossiliferous red hematite, having a thickness of from 3½ to 4 feet. The fossils—the most abundant of which is a *Spirifer* (*S. Nictavensis*)—" seem to give indubitable evidence that the Nictaux iron ore is of Lower Devonian age." At Moose River, as already noticed, the ore of similar age exists largely in the condition of magnetite.

Hematite of Carboniferous age.

Passing now to the Carboniferous we find in Nova Scotia, near Clifton, (formerly Old Barns) and the mouth of the Shubenacadie, ores which are mixtures of red hematite, red ochre, limonite, göthite, and considerable quantities of earthy impurities. The deposits visited, however, did not appear to be of much economic importance. They occur in the form of veins in the sandstones and laminated limestones of Lower Carboniferous age. Near "Black Rock," on the Shubenacadie, openings have been made on several of these veins, but the material extracted so far is of very poor quality. Near Clifton, also, a shaft has been sunk to a depth of 35 feet on a vein in coarse red sandstone holding concretions of clay. The vein is said to be about 6 feet thick, but could not be seen at the time of my visit as the shaft was nearly full of water. In sinking, a considerable quantity of ore had been taken out, but was of inferior quality, being largely mixed with sandstone, sulphate of baryta, &c.

At Gallas or Gallows Point, on the eastern side of Hillsborough Bay, Prince Edward Island, a series of rocks occurs, consisting of red and brown sandstones, red and mottled red and grey clays, and occasional thin bands of impure concretionary limestone. These beds have been regarded by Dr. Dawson as Upper Carboniferous, although it is admitted at the same time that they have a somewhat Permian aspect. Some of

* Acadian Geology, 2nd Ed., p. 498.

them contain nodules or concretions of red hematite, many of which, as the rocks are disintegrated by the waves, are left strewn upon the beach. Trunks of fossil coniferous trees also are abundant in places, and some of them have been infiltrated with hematite. The quantity of ore, however, which could be obtained from these sources is too small to be regarded as of any economic importance.

In Cape Breton deposits of hematite are said to occur in rocks of Carboniferous age, but I have been unable to obtain any reliable details concerning them.

Triassic hematite.

In the great ridge of Triassic trap bordering the eastern side of the Bay of Fundy, veins of specular iron ore occur, but are nowhere known to be of sufficient dimensions to be considered workable.

Modern red ochres.

The modern red ochres referred to on page 212 are unimportant. They have probably been produced in many instances from the ordinary bog ores by the action of bush fires.

Mineral associations of hematite.

Most of the minerals associated with the different varieties of hematite have already been noticed incidentally, but a few additional facts concerning them may not be out of place here. The following list probably includes most of those which have been observed:

Ankerite.	Graphite.
Barytes.	Hornblende.
Calcite.	Limonite.
Chalcocite.	Magnetite.
Chalcopyrite.	Malachite.
Chlorite.	Mica.
Dolomite.	Pyrites.
Epidote.	Pyroxene.
Feldspar.	Quartz.
Fluor-spa.r.	Siderite.
Gœthite.	Talc.

Most of these, it will be noticed, are the same as those occurring with magnetite, and several are rather constituents of the rocks in which the hematite occurs than mineral associates, strictly speaking, of the latter.

Ankerite.—This mineral may be regarded as dolomite in which part of the magnesia is replaced by protoxide of iron, and generally also by protoxide of manganese. As already stated, it is found at the Acadia mines, Londonderry, and also in Pictou County. At the former locality it has long been mined as a flux for the blast furnace. Before exposure to the weather it is white or greyish-white in colour, but the protoxide of iron readily becomes converted into hydrous and anhydrous peroxide, causing it to assume yellowish, reddish and brownish colours. This change in the condition of oxidation of the iron, together with the loss of carbonates of lime and magnesia and the taking up of water, has resulted in the pro-

Ankerite used as a flux.

Analyses of ankerite.

duction of large quantities of limonite. The following are analyses of ankerite from Londonderry:

	I.	II.	III.	IV.
Carbonate of lime.........	54.00	43.80	49.20	51.61
Carbonate of magnesia...	22.00	30.80	30.20	28.60
Carbonate of iron	23.20	23.45	20.30	19.59
Carbonate of manganese	....	0.80		....
Siliceous sand...............	0.50	0.10	....	0.13
	99.70	98.95	99.70	99.93

I.—White variety, by Dawson. III.—Brown variety, by C. J. Jackson.
II.—Yellow " " C. J. Jackson. IV.— " " " H. How.

Barytes or Heavy-spar.—This species occurs at the Haycock mine in Templeton, but was observed in one spot only. Specimens were obtained in which crystals of barytes were associated with specular iron, calcite, beautiful green fluor-spar, and reddish feldspar. Possibly these were from a vein.

Barytes with specular iron, calcite, fluor-spar and feldspar.

In Nova Scotia barytes is sometimes associated in small quantity with specular ore and ankerite at the Acadia iron mines, and is very common with the ores of Clifton and the mouth of the Shubenacadie. At the latter place it often occurs in white and reddish crystals, about a quarter of an inch long, lining the walls of cavities in the ore or the containing limestone. In some cases these crystals have been curiously coated over with velvety oxide of iron, giving them a rounded outline.

Crystals of barytes coated with oxide of iron.

The fossil coniferous trees of Gallas Point, Prince Edward Island, stated on page 219 to have been infiltrated with peroxide of iron, often contain large quantities of barytes.

Fossil trees containing barytes.

Calcite.—The occurrence of hematite in beds of limestone has already been referred to. At the Dalhousie mine cavities in the limestone near the hematite sometimes contain good crystals of dog-tooth spar. At the Haycock mine calcite occurs containing masses of specular ore, and penetrated in all directions by crystals of beautiful, glassy, green pyroxene, from a sixteenth of an inch or less up to a quarter of an inch thick; rhombic crystals of mica occur in an analagous manner, though more sparingly than the pyroxene. Calcite sometimes forms veins in ankerite at Londonderry, or in crystals lines the walls of little cavities. In the form of dog-tooth spar also, as well as in veins, it is found in the red ore of the Peter Totten lot, Londonderry. Near the mouth of the Shubenacadie, at the locality referred to under barytes, calcite is very common, and occurs crystallized in several forms. The crystals are often stained red with peroxide of iron, and some of them have their faces much curved. Curious aggregations of rhombohedral crystals piled one upon another are also found here.

Crystals of calcite with rounded faces.

Chalcocite or Copper-Glance.—See under Dolomite and Feldspar.

Chalcopyrite.—Small quantities of chalcopyrite or copper pyrites are occasionally met with in the specular ore of Londonderry, and sometimes also in the red ore.

Chlorite.—The specular schists of the Eastern Townships are said to frequently contain disseminated scales of chlorite. The only chloritic ores from this region which I have seen are titanic iron ores. According to Mr. Macfarlane chlorite occurs in a vein of earthy hematite at Marmora.

Dolomite.—Specular schists are stated in the Geology of Canada to be interstratified with dolomite in the Eastern Townships, and specular ore, copper-glance, feldspar and dolomite to occur together in the township of Leeds.

Epidote.—This mineral is said to be associated with specular ore in the Eastern Townships. In New Brunswick also, small veins of specular ore are found in epidotic rocks supposed to be of Huronian age.

Feldspar.—Under this general term several species may perhaps be included, but their true nature has not been investigated. At the Haycock mine reddish orthoclase is the most frequent association of the specular ore, not only forming the principal constituent of the enclosing rock, but masses of it being embedded in the ore. In Leeds (Megantic) tabular plates of hematite are associated with feldspar, copper-glance and dolomite (Geol. of Can., p. 510.) **Orthoclase at the Haycock mine.**

Fluor-spar.—As already mentioned, beautiful green fluor-spar occurs at the Haycock mine associated with specular ore, heavy-spar, calcite and feldspar. This is the only locality in which it was observed.

Göthite.—This hydrated oxide of iron occurs associated with the hematite and limonite of Clifton and the mouth of the Shubenacadie, Nova Scotia, often being found in the form known as *nadeleisenstein* or needle iron ore. Veins of it associated with black oxide of manganese and calcite also cut the lamellar Lower Carboniferous limestones at Black Rock near the mouth of the Shubenacadie. A specimen before me from this locality consists of beautiful radiating needles with adamantine lustre, the ends of which are capped with rhombohedral crystals of calcite. **Needle iron ore.**

Graphite.—The hematite of the Woodstock mines, New Brunswick, is stated by Professor Hind to be often seamed with thin layers of graphite; and the mixture of magnetite and hematite at the Hull mines known as red ore frequently contains scales of graphite. According to Professor Chapman it is also present in the specular ore of the Haycock mine, Templeton.

Hornblende.—This mineral, which is so frequently associated with magnetite, I have nowhere noticed in deposits of hematite, although it sometimes forms an important constituent of the containing rock.

Limonite.—The red ores of Londonderry are frequently associated with limonite; they often contain a considerable proportion of water themselves, and may then be regarded as mixtures of hematite and limonite. The same is probably true of the red ores in many other localities. The specular ore of Londonderry is also frequently accompanied by limonite. The ores of Clifton and the mouth of the Shubenacadie have already been described **Mixtures of anhydrous and hydrous oxides of iron.**

as mixtures of red hematite, red ochre, limonite, &c. Sometimes radiating masses may be obtained shewing alternate layers of red hematite and limonite.

Malachite.—In places the veins at Londonderry containing specular ore also hold very minute quantities of copper pyrites which is generally coated with malachite. In the red ore of the Peter Totten lot also, copper pyrites and malachite may occasionally be noticed.

Mixtures of hematite and magnetite.

Magnetite.—The occurrence of magnetite and hematite together is very frequent, and has been noticed several times in the preceding pages. At Londonderry and on the East River of Pictou County the specular ores often contain a considerable proportion of magnetic oxide. The same is the case with specimens of ore brought by Mr. Charles Robb last autumn from the Whykokogomagh mines, Cape Breton. The fossiliferous Devonian hematites of the Annapolis Valley, Nova Scotia, have also in many cases been altered to magnetite, and every gradation may be observed from normal non-magnetic hematite with a red streak, to strongly magnetic ores with dark brown or black streak. The alteration is probably due to the neighboring igneous rocks, and the presence of organic matter.

Mica.—Under this term may be comprised several species, which, however, are not easily distinguished without analysis. Muscovite and phlogopite probably both occur, and hydrous micas of somewhat variable composition are frequently found associated with specular and micaceous iron ores in the Eastern Townships.

Hematites freer from pyrites than magnetites.

Pyrites.—The Laurentian and Huronian hematites appear in general to be much freer from pyrites than the magnetites of corresponding age. At the Dalhousie mine there is none visible in the ore, but on sinking a trial hole a short distance south-west of the present workings, instead, as was expected, of coming upon the hematite, a bed of pyrites four feet thick is said to have been struck—a fact suggesting that the hematite may be the result of the decomposition of pyrites. The specular ore of the Haycock mine is exceedingly free from this as well as from other impurities, and it is difficult to find specimens in which pyrites can be detected by the eye. The only specimens which I have seen of the jaspery hematite of Bachewahnung contained a good deal, but specimens from Gros Cap in the museum of the Geological Survey shew none whatever. The specular ore of Londonderry, so far as may be judged from what has been mined, is very pure; but a good deal of pyrites was observed in that which has been mined near the East River of Pictou.

Pyroxene.—This mineral is occasionally found associated with hematite. At the Haycock mine the ore is sometimes penetrated by long crystals of green pyroxene about a sixteenth of an inch in diameter. Similar crystals, though often much larger, occur in calcite at the same locality (see p. 220.)

Quartz.—The occurrence of hematite, interstratified with jasper and quartzite has already been mentioned (p. 213). The metamorphic rocks of the Eastern Townships, and also of New Brunswick, are often cut by veins composed of quartz and specular ore, and beds of hematite of different ages frequently contain little veins of quartz. The great hematite beds of Lower Helderberg age in Nova Scotia are generally made up of grains of sand enveloped with red oxide of iron. The proportion of these siliceous grains at times becomes so great that the ore passes into a ferruginous sandstone.

Siderite or Spathic Iron.—This mineral occurs in the Londonderry veins, sometimes with specular ore, and Dr. Dawson informs me that large quantities of it were mined many years ago near Great Village River, and smelted in the blast furnace. From its decomposition limonite and earthy red ore have often been produced, and at the Peter Totten lot, Londonderry, specimens may be obtained shewing every gradation from spathic ore to red ore containing no trace of the carbonate, though still displaying its cleavage planes.

Limonite and earthy red ore formed from spathic ore.

Talc.—Some of the hematites of the Eastern Townships are said to contain flakes of talc; but I have seen no specimens shewing it.

RECENT ANALYSES AND ASSAYS OF HEMATITES.

Several analyses and assays of hematites from different parts of the country have recently been made in the laboratory of the Survey. Among the ores examined is a slaty hematite from the great Lower Helderberg bed of Pictou County, Nova Scotia. It was from a locality known as "Webster's" on area No. 101 of the Government plan, and was made up largely of grains of sand enveloped with peroxide of iron. A partial analysis gave as follows:

Analysis of hematite from area 101, Pictou county, N.S.

Peroxide of iron	52.300
Protoxide of iron	traces.
Protoxide of manganese	0.148
Phosphoric acid	0.198
Sulphur	0.338
Water	1.980
Metallic iron	36.610

Another specimen from "Blanchard's" on what was formerly known as the Hudson area (now area 45 of the Government plan) was examined by Mr. Hoffmann. It was more earthy than the preceding and contained a few fossil shells.

Analysis of ore from the Hudson area.

A partial analysis gave,

Peroxide of iron	60.710
Protoxide of manganese	0.183
Phosphoric acid	0.633
Sulphur	0.085
Insoluble residue	29.976
Metallic iron	42.500

An assay of another specimen of earthy red hematite from a deposit on area 108, supposed to be a continuation of the bed exposed at Blanchard's, gave 42.77 per cent. of iron. The proportion of phosphorus in this Lower Helderberg hematite is very variable, according as it is fossiliferous or not, a fact which should be borne in mind in working it. In many parts of its course the bed shews no fossils whatever, while in other parts it holds them in great abundance. A highly fossiliferous sample examined some time ago gave me no less than 3.25 per cent. of phosphorus.

Phosphorus.

Analysis of ore from the Peter Totten lot, Londonderry.

An analysis of the ore from the Peter Totten lot at the Acadia mines, Londonderry, may be given here, since it is generally known as a "red ore," although containing a considerable proportion of water. The specimen was of a dark brownish-red colour, and had a specific gravity of 3.29. Its analysis gave,

Peroxide of iron		69.86
Protoxide of manganese		2.25
Alumina		traces.
Lime		11.70
Magnesia		0.42
Silica		0.07
Carbonic acid		9.20
Phosphoric acid		none.
Sulphuric acid		0.04
Water	hygroscopic	1.33
	combined	5.74
		100.61
Metallic iron		48.91
Sulphur		0.015

This ore would probably be easy to smelt, and, on account of its purity and the considerable proportion of manganese which it contains, would produce the best of pig iron for conversion into steel. As yet only a small quantity has been mined, and little is known of the extent of the deposit, although it is well worthy of being thoroughly examined.

Specular ore from Cook's Brook, Londonderry.

The specular ore of Cook's Brook (p. 215) has been analysed by Mr. Hoffmann and found to be exceedingly pure. The specimen examined had a specific gravity of 4.93, and contained,

Peroxide of iron		96.93
Protoxide of manganese		traces.
Alumina		0.32
Lime		0.04
Magnesia		0.11
Phosphoric acid		0.007
Sulphuric acid		none.
Water	hygroscopic	0.03
	combined	0.79
Insoluble residue		1.26
		99.497
Metallic iron		67.85

The insoluble residue consisted of,

Silica	1.20
Alumina with traces of peroxide of iron	0.07
	1.27

No doubt this is richer than the average of the ore which could be obtained on a large scale.

An assay of the specular ore from area 47, East River, Pictou County, gave 66.74 per cent. of iron. Assay of specular ore from East River, N.S.

On the thirtieth lot of the sixth range of Elmsley, Ontario, a fine red hematite occurs, but Mr. Vennor tells me that the deposit is too small to be considered workable. A specimen of the ore was sent to the office of the Geological Survey by Mr. A. B. Savage, of Montreal, and a partial analysis gave, Analysis of ore from Elmsley, Ontario.

Peroxide of iron	89.10
Phosphoric acid	0.02
Sulphur	0.07
Titanic acid	none.
Metallic iron	62.36

The hematite was mixed with white talcose matter and a little mica.

In the Report of Progress for 1871-72, p. 104, Professor Bell mentions the occurrence of a slaty iron ore on the east side of Lake Nipigon. A specimen of this ore has been examined and found to contain 51.51 per cent. of peroxide of iron (metallic iron 36.06), traces of manganese, 0.076 per cent. of phosphoric acid, and 8.00 of alumina, the remainder being chiefly silica.* Slaty hematite from Lake Nipigon.

When at the Dalhousie mine in July last, a specimen of the ore was selected by the manager (Mr. Gerald C. Brown,) and myself, which appeared to represent fairly the average of that then being mined. It contained 86.20 p.c. of peroxide, equal to 60.34 of metallic iron, and 10.30 of insoluble matter. Ore from Dalhousie mine.

An ore from the Whykokomagh mines, Cape Breton, collected by Mr. C. Robb, contained 42.64 per cent. of iron and 0.26 p.c. of phosphoric acid. It was slightly attracted by the magnet gave a dark purplish-grey powder, and apparently consisted of a mixture of micaceous iron ore, magnetite, and a considerable quantity of siliceous matter. A second sample contained 41.28 per cent. of iron. Whykokomagh mines.

In the event of ore ever being smelted on Lake Nipigon, limestone could be obtained in places for a flux. The following is an analysis of a specimen from the south side of an island known as the Inner Barn:

Carbonate of lime	69.69
Carbonate of magnesia	3.32
Soluble alumina and peroxide of iron	0.70
Insoluble residue	26.45
	100.16

The following table is compiled from different sources, and will serve to further illustrate the composition of Canadian hematites:

TABLE OF ANALYSES OF HEMATITES.

Constituents.	I.	II.	III.	IV.	V.
Peroxide of iron	84.42	84.10	88.08	89.80	85.45
Protoxide of iron	....	....	6.86	7.06	5.24
Protoxide of manganese	....	....	0.24	trace.	0.15
Alumina	....	....	....	....	....
Lime	3.02	4.93	0.55	trace.	0.41
Magnesia	0.50	....	0.13	0.22	0.17
Phosphoric acid	0.03*	....	0.16	trace.	0.13
Sulphur	0.065	....	0.03	trace.	0.07
Carbonic acid	2.93	3.87	....	....	....
Silica	....	4.00	....	....	....
Titanic acid	....	....	3.17	2.34	2.12
Graphite	....	....	0.35	0.43	0.28
Water	....	....	....	....	....
Insoluble matter	7.16	....	0.26	0.11	5.77
	98.125	96.90	99.83	99.96	99.79
Metallic iron	59.09	58.80	66.98	68.34	63.88

Constituents.	VI.	VII.	VIII.	IX.	X.
Peroxide of iron	82.25	86.80	} 75.67	92.01	96.63
Protoxide of iron	....	....		....	0.89
Oxide of manganese	....	....	0.52	2.16	....
Alumina	....	....	0.45	0.21	....
Lime	trace.	none.	1.37	0.71	....
Magnesia	....	....	0.46	0.20	....
Phosphoric acid	0.026*	trace.	0.22	0.08	none.
Sulphur	....	0.092	0.29	0.16	0.06†
Carbonic acid	....	....	1.59	0.79	....
Silica	....	....	19.43	3.68	3.20‡
Titanic acid	....	....	trace.	trace.	....
Water	0.66	....	....	....	....
Insoluble matter	16.05	12.75	....	....	....
	98.986	99.642	100.00	100.00	100.78
Metallic iron	57.60	60.76	54.36	64.41	68.83

I.—Red hematite from the MacNab mine near Arnprior. By Dr. Hunt. See Report of Progress, 1866–69, p. 260.

II.—Red hematite from the same locality as No. I. By Dr. Hunt. Geol. of Can., 1863 p. 678.

III., IV., and V.—Specular ore from the Haycock mine, Templeton. By Professor Chapman. (Supplementary Report on the Haycock Iron Location. Toronto, 1873.) Nos. III. and IV. are analyses of selected examples—the latter of a fragment of a crystal—and No. V. of a large sample supposed to represent the average of a heap of about 300 tons. Professor Chapman says that, "as a rule, the ore is practically non-magnetic, but in places it exerts a feeble action on a delicately suspended needle, and shews slight polarity." Some of my specimens, however, are pretty strongly magnetic, but are, I believe, from a different bed from those examined by Professor Chapman.

VI.—Red hematite from the Cowan or Dalhousie mine. By Gordon Broome, F.G.S. Report of Progress, 1871–72, p. 123.

VII.—Red hematite from Gros Cap, Lake Superior. By Dr. Hunt. Report of Progress, 1866–69, p. 260.

* Phosphorus. † Pyrites. ‡ Silica and insoluble matter.

VIII.—Red hematite from East River, Pictou County, Nova Scotia. By Stevenson Macadam, F.R.S.

IX.—Specular ore from East River, Pictou County, Nova Scotia. Also by Macadam.

X.—Specular ore from the same locality as No. IX. By Dr. T. E. Thorpe, of the Andersonian University, Glasgow.

TITANIC IRON ORE OR ILMENITE.

This ore is found chiefly in rocks of Laurentian age, more especially in the Upper Laurentian, and often forms deposits of very considerable magnitude. Some of the ores of Brome and Sutton, in rocks of the Quebec group, also belong here, as they have been found to contain from twenty to thirty per cent. of titanic acid. In some instances the titanic acid found in the analysis of magnetic ores appears to be present as one of the constituents of the magnetite, but in other cases it is due to the presence of ilmenite mechanically mingled with the magnetite. An example of a mixture of this kind, noticed by Dr. Hunt, in the rocks of the Eastern Townships has already been cited on page 206. Similar deposits would also be produced by the consolidation of the iron sands of the gulf.

Age of titanic iron ore.

Occurrence of magnetite and ilmenite together.

The largest deposit of ilmenite known in Canada is that at Bay St. Paul.* It occurs in a rock mainly made up of triclinic feldspar, and is said to have a thickness of about ninety feet. According to Dr. Hunt the ore is sometimes penetrated by crystals of a greenish triclinic feldspar, and frequently also contains grains of orange-red transparent titanic acid. No. I. is an analysis by Dr. Hunt, and No. II. by the late Dr. Frederick Penny of Glasgow:

Ilmenite of Bay St. Paul.

Analyses by Dr. Hunt and Dr. Penny.

	I.	II.
Peroxide of iron	10.42	20.35
Protoxide of iron	37.06	29.57
Alumina	......	4.00
Lime	......	1.00
Magnesia	3.60	3.17
Titanic acid	48.60	40.00
Silica	.....	1.91
	99.68	100.00
Metallic iron	36.12	37.25

According to Dr. Penny the ore contains no manganese, phosphorus or sulphur.

A specimen of titanic iron ore from St. Jerome, recently examined, was found to contain,

St. Jerome.

Metallic iron	24.65
Titanic acid	32.36

Another from St. Julien, six miles from St. Lin, (from a property belonging to Joseph Barsalou, Esq., of Montreal) gave,

St. Julien.

Metallic iron	38.27
Titanic acid	33.67

* See Geol. of Can., 1863, pp. 501 and 754; also this Report, p. 249. Large deposits of ilmenite, associated with labradorite rocks, have been observed on the Saguenay River and on the shores of Lake Kenogami.

This specimen was much weathered, but the gangue apparently consisted of a partially decomposed feldspar. In the proportions of iron and titanic acid it comes very close to the titanic ore from the Bay of Seven Islands, which gave Dr. Hunt 38.70 per cent. of metallic iron and 34.30 of titanic acid. (Report of Progress, 1866-69, p. 260). The Bay of Seven Islands ilmenite occurs in labradorite rock, and is said to form a very extensive deposit. Dr. Hunt alludes to its being "pretty strongly magnetic," and this is also the case with the ore from St. Julien.

Bay of Seven Islands.

Titanic iron ores in the Eastern Townships.

In the Geology of Canada, page 501, some of the ores in the metamorphic rocks of Brome and Sutton are said to contain one or two hundredths of titanic acid. This amount would of course not detract from their value; but it must be borne in mind that in this same region there are also deposits which on account of their large proportion of titanic acid should be classed as titanic iron ores. Thus a finely granular ore of a dark iron-grey colour from the ninth lot of the eleventh range of Sutton gave,

Sutton, lot 9, range 11.

Metallic iron	40.87
Titanic acid	27.20

With the glass it shewed numerous grains of silica, and occasional scales of mica or perhaps chlorite. It was but slightly affected by the magnet and gave a brown streak. A similar ore from the eighth lot of the ninth range of Sutton (Lee's lot) gave,

Sutton, lot 8, range 9.

Metallic iron	39.14
Titanic acid	29.86

Brome, lot 1, range 3.

Another from the first lot of the third range of Brome contained,

Metallic iron	41.46
Titanic acid	24.16

Like the others it gave a brown streak, and was but very slightly affected by the magnet. It contained a little vein of quartz holding small quantities of carbonate of copper.

LIMONITE.

This ore, which in some of its forms is often called brown hematite, consists essentially of peroxide of iron combined with water, the theoretical proportions being 85.6 of the former to 14.4 of the latter.

Bog ores considered separately.

The term limonite is generally made to include bog ores, which, however, will be considered separately here, as a distinction seems necessary, or at least convenient.* The ores to be described as limonite usually occur in veins, being the result of the alteration, generally *in situ*, of other ores of iron or of such minerals as ankerite; if they contain organic matter at all, it is, so far as known, in very small quantity. The bog ores, on the other hand, appear generally to contain a considerable quantity of organic

* The name limonite, being from λειμών, a meadow, is, strictly speaking, especially applicable to bog ores, but could not well be restricted to them now.

matter; they occur, moreover, as patches or beds in low grounds, and are not the result of the alteration of pre-existing ores *in situ*.

No important deposits of limonite are known to occur in Canada in rocks older than the Middle or Upper Silurian, or newer than the Lower Carboniferous.* Those occurring in these rocks are chiefly in the Province of Nova Scotia. In the Middle or Upper Silurian of this Province the principal deposits are the result of the alteration of the spathic ore and ankerite of the great Londonderry vein, which, together with its country rock, has already been partly described under hematite, and which, extends for a distance of many miles. The alteration has not been continuous along the entire vein, but only local, and frequently, instead of limonite, earthy red hematite, or mixtures of red and brown hematite occur. The depth to which the alteration has extended is also variable, sometimes reaching only a few feet from the surface, while at the Martin's Brook workings, in September last, it was being mined at a depth of two hundred feet. The limonite of this vein varies much in texture, sometimes occurring in botryoidal and stalactitic masses with lustrous surface, as at Ross' Farm; at others fibrous and with a beautiful silky lustre, as on the hill on the east side of Cumberland Brook; in other cases compact and lustreless, or earthy and porous. At Martin's Brook much of the ore consists of honey-combed masses with reticulating walls of compact limonite and cavities containing earthy or ochreous ore of a brownish-yellow colour : this ore has probably been produced from ankerite, and frequently contains nests and strings of specular ore which originally had the ankerite as a veinstone.

Age of Canadian limonites.

The Londonderry vein.

On going eastward we again find limonite, probably of the same age as that at Londonderry, in Pictou County, on area 105 (Cullen's, near the West Branch of the East River). Here, in the banks of a small stream, a band of quartzite is exposed which has been much broken up or shattered, and has the cracks filled with numerous veins of limonite. The largest of these observed was about a foot thick, and it would be difficult to obtain ore in quantity sufficiently free from gangue for smelting. It is, however, possible that on tracing the deposit it will be found that the rocks have in places been less fissured, and that the numerous small reticulating veins are there represented by single veins of greater thickness. At all events masses of ore too large to have come from such veins as those exposed are scattered about on the surface for a considerable distance from the stream. Should large deposits be discovered here they would be especially valuable on account of their proximity to the Provincial Railway.

Pictou County, area 105.

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* Limonite is said to occur at the Jacksontown mines near Woodstock, N.B., in rocks of Lower Silurian age; but the only specimen which I have seen should be classed as hematite. According to Gesner (First Report, p. 72) an important deposit of ore, consisting of the hydrate of iron, argillaceous oxide of iron, and hematite occurs on the Nerepis road, near Coot Hill, N.B., in argillaceous slate which is older than the Carboniferous.

Pictou County, area 100.

Further to the east, on area 100, according to Dr. Dawson, masses of limonite are found in the vicinity of the vein of specular ore, of which a description has already been given, but the ore has not been discovered in place. On crossing the East Branch of the East River, however, a number of openings have been made on a vein of limonite which, unlike the preceding, occurs at the line of junction of the Silurian and Carboniferous. "The vein follows the sinuosities of the margin of the older rocks, and varies in thickness and quality in different places; being apparently richest opposite the softer slates and where these are in contact with a black manganesian limestone, which here, as in many parts of Nova Scotia, forms one of the lowest members of the Carboniferous series. The ore is sometimes massive, but more frequently in fibrous concretionary balls of large size, associated with quantities of smaller concretionary or 'gravel ore.' In some places the ore of iron is associated with concretions or crystalline masses of Pyrolusite and Manganite." * The right-of-search areas on which the limonite referred to by Dr. Dawson occurs are numbers 46 and 48 of the Government plan. Besides the ore found in place, large quantities of loose masses, sometimes of considerable size, are scattered about on the surface, or buried in the drift. Unfortunately at the time of my visit in September, none of the openings on the vein were accessible, but on what is known as the Fraser Saddler area (a mining area taken out on the right-of-search areas 46 and 48) the ore was exposed close to a small brook, and shewed a thickness of about eight feet of very fine, compact, botryoidal and fibrous limonite, occasionally containing small quantities of sulphate of baryta (see p. 233). This is the portion of the vein discovered by Mr. Hartley in 1868, and described by him in the Report of the Geological Survey for 1866–69, page 440. Close to the spot where the ore was uncovered by this gentleman, Mr. G. M. Dawson has since (in 1872) made an excavation and found the vein to be no less than fifteen feet thick, two feet eight inches consisting of loose concretionary limonite known as "ore gravel," and the remainder of the more solid varieties mentioned above. One wall of the vein was composed of solid slate, and the other of stiff red and white clay.

Limonite of the East Branch of the East River.

Fraser Saddler area.

Thickness of the vein.

A short distance further down the river, or nearer to Springville, a shaft has been sunk by Mr. David Fraser to a depth of 42 feet, and on cross-cutting the vein reached and found to be twenty-two feet six inches thick. Silurian slates, Dr. Dawson tells me, occurred on one side of the vein, and on the other Lower Carboniferous limestone; the latter, however, being separated from the ore by a selvage of clay. Still nearer to Springville, in another opening made close to the roadside by Mr. Gilpin, the vein is reported to have a thickness of twenty-three feet.

* Dr. Dawson.—Can. Nat., new Ser., vol. vii., p. 137.

At Brookfield near the line of the railway between Halifax and Truro, large masses of limonite are said to occur scattered over the surface, and, according to Dr. Dawson, probably near the junction of the Lower Carboniferous with older rocks. The occurrence of important veins *in situ* has, however, so far as I can learn, not yet been proved. Brookfield, N.S.

The ores of Lower Carboniferous age at Clifton and the mouth of the Shubenacadie have been described under hematite (p. 218), though consisting of both hydrous and anhydrous oxides of iron. Clifton and the mouth of the Shubenacadie.

The more important minerals accompanying limonite have already been noticed; they are ankerite, barite, calcite, göthite, hematite, manganite pyrolusite, and siderite. Minerals accompanying limonite.

COMPOSITION OF LIMONITES.

Several analyses of Nova Scotia limonites have been made in the laboratory of the Geological Survey, Four of the specimens examined were from the Acadia mines, Londonderry, one from the West Branch of the East River (Cullen's area), and one from the East Branch of the East River (Fraser Saddler area). The analyses of the Londonderry specimens will be given first and then those of the East River specimens. Analyses of Londonderry ores.

Ross' Farm, Acadia Mines.

The ore at this locality occurs mostly in the form of lustrous botryoidal or mammillary and stalactitic masses of a dark brown colour and exhibiting a fibrous structure when broken. An analysis of a specimen with a specific gravity of 3.98 gave Mr. Hoffmann as follows:

Peroxide of iron	84.73
Protoxide of iron	traces.
Protoxide of manganese	0.23
Alumina	0.23
Lime	0.14
Magnesia	0.14
Phosphoric acid	0.19
Sulphuric acid	0.01
Water { hygroscopic	0.33
Water { combined	11.07
Insoluble residue	2.67
	99.74
Metallic iron	59.31
Phosphorus	0.083
Sulphur	0.004

The insoluble residue consisted of,

Silica	2.54
Alumina with traces of peroxide of iron	.09
	2.63

Martin's Brook, Acadia Mines.

Much of the ore at this locality is ochreous, but it also occurs in dark brown botryoidal masses with fibrous structure within. A specimen of the latter variety with a specific gravity of 3.91 gave Mr. Hoffmann:

Peroxide of iron	82.65
Protoxide of iron	traces.
Protoxide of manganese	0.25
Alumina	0.56
Lime	0.15
Magnesia	0.10
Phosphoric acid	0.38
Sulphuric acid	0.02
Water { hygroscopic	0.31
Water { combined	10.51
Insoluble residue	4.79
	99.72

Metallic iron	57.850
Phosphorus	0.166
Sulphur	0.008

The insoluble residue was found to consist of,

Silica	4.51
Alumina with traces of peroxide of iron	0.28
	4.79

Phosphorus in bar iron.

Large quantities of this ore have been smelted at Londonderry, the average yield in the furnace being nearly 50 per cent. A sample of the bar iron made from it contained only 0.018 per cent. of phosphorus.

Cumberland Brook, North Vein, Acadia Mines.

This specimen was a hard compact limonite of a dark brown colour and without lustre, except on the surfaces of occasional cavities. It had a specific gravity of 3.77, and yielded on analysis:

Peroxide of iron	82.13
Protoxide of iron	1.00
Protoxide of manganese	0.72
Alumina	0.66
Lime	0.88
Magnesia	0.25
Silica	1.93
Phosphoric acid	0.86
Sulphuric acid	0.04
Water { hygroscopic	0.44
Water { combined	11.07
	99.98

Metallic iron	58.27
Phosphorus	0.37
Sulphur	0.016
Insoluble residue	2.05

Cumberland Brook, South Vein, Acadia Mines.

The sample of ore from this place analysed was an ochreous limonite of a yellowish brown colour and having a specific gravity of 3.31. It contained:

Peroxide of iron	79.68
Protoxide of iron	none.
Protoxide of manganese	2.51
Alumina	0.63
Lime	0.57
Magnesia	0.34
Silica	3.05
Phosphoric acid	0.44
Sulphuric acid	0.01
Water { hygroscopic	0.78
Water { combined	11.65
	99.66
Metallic iron	55.776
Phosphorus	0.192
Sulphur	0.004
Insoluble residue	3.040

Fraser Saddler Area, East River, Pictou County.

The specimen was a beautiful fibrous limonite of a light brown colour, and specific gravity of 3.84. It contained but little sulphur or manganese, although heavy-spar, manganite, and pyrolusite are all found occasionally associated with the ore in parts of the vein. An analysis gave:

Analysis of ores from the East River, Pictou County.

Peroxide of iron	85.01
Protoxide of iron	none.
Protoxide of manganese	0.38
Alumina	0.69
Lime	0.49
Magnesia	0.19
Phosphoric acid	traces.
Sulphuric acid	0.055
Water { hygroscopic	0.36
Water { combined	10.77
Insoluble residue	2.14
Organic matter	traces.
	100.085
Metallic iron	59.50
Sulphur	0.022

The insoluble residue was found to consist of,

Silica	1.98
Alumina, with traces of peroxide of iron	.18
Lime	traces.
	2.16

Area 105 (*Cullen's*), *West Branch of the East River, Pictou County.*

A specimen (loose) of the ore from this locality with a specific gravity of 3.955 has been examined by Mr. Hoffmann. It was a compact limonite of a dark brown colour and contained:

Peroxide of iron	76.930
Protoxide of iron	4.972
Protoxide of manganese	0.068
Alumina	1.019
Lime	0.313
Magnesia	0.052
Silica	5.836
Phosphoric acid	0.989
Sulphuric acid	0.114
Water { hygroscopic	0.175
Water { combined	9.287
Organic matter	0.180
	99.935
Metallic iron	57.718
Phosphorus	0.431
Sulphur	0.046
Insoluble residue	6.350

Water in limonites.

The amount of water indicated by all these analyses is less than that required theoretically to form limonite, the average deficiency being about three per cent.; at the same time it is greater than in göthite, so that the ores may be regarded as mixtures of limonite with oxides of lower degrees of hydration, or of limonite with anhydrous peroxide.

Phosphorus.

The amount of phosphorus is not high for ores of the class; ranging from mere traces in the ore from the Fraser Saddler area to 0.431 per cent. in that from the Cullen area, or an average of 0.207 per cent. The average percentage of sulphur is very low, being only 0.016.

BOG IRON ORE.

Descriptions of the principal deposits of this ore known in the country were published in the *Geology of Canada*, in 1863, and since that time but few additional facts have been developed.

Age and characters of bog ores.

Bog ores are mainly of recent age, occurring at or near the surface, and generally in sandy regions, ferruginous sands often being the source of the iron. Sometimes they are found in a pulverulent condition, and then known as ochres and better adapted for pigments than for smelting. The colour of these ochres is generally yellowish or reddish-brown, though when freshly exposed they often present other tints owing to portions of the iron having been reduced to the condition of protoxide by organic matter. The variety employed for smelting occurs in concretionary

lumps or masses often shewing a curious cavernous structure, and either dull and earthy, or at times highly lustrous when fractured. The colour is usually yellowish or reddish-brown, and dark brown or black when much manganese is present. The concretions are either scattered through the soil, or else form continuous layers, generally only a few inches in thickness, though sometimes several feet—in one instance, in Côte St. Charles, Vaudreuil, no less than eight feet! *

Though the iron in Canadian bog ores occurs chiefly as peroxide in combination with water, and generally also with organic acids, protoxide of iron is very commonly present, often, apparently, in combination with silica, which separates in a gelatinous condition on treating the ore with hydrochloric acid. Oxides of manganese also are frequently present, though in variable quantity, ranging from mere traces up to nearly thirty per cent. The proportion of iron obtained on analysis is likewise variable, averaging about fifty per cent. In the blast furnace, however, the yield has usually been only from 30 to 40 per cent., as the ores often contain a considerable proportion of silica, in the form of sand, which is not easily removed even by washing. When sulphur is present, it is, so far as known, only in very small quantity. The amount of phosphoric acid ranges from mere traces to nearly two per cent. The volatile matter (water and organic matter) averages about twenty per cent. (19.92 as deduced from ten analyses). In an ochre from Ste. Anne, Montmorenci, Dr. Hunt obtained as high as 36.15 per cent. of volatile matter.

Protoxide of iron.

Yield of bog ores in the furnace.

No ore is more easily reduced than bog ore; for not only is it porous and readily permeable by reducing gases, but the organic matter undoubtedly aids in its reduction. The conversion of bog ore into magnetic oxide by the reducing action of the organic matter has been described on page 195, and Dr. Hunt found that the ochre from Ste. Anne, when heated to redness in a closed vessel, evolved inflammable gases and was converted into a mixture of pyrophoric metallic iron and charcoal.

Organic matter as a reducing agent.

A large proportion of the pig iron made from bog ores is generally white or mottled, this, no doubt, being due to manganese and phosphorus. During the time that the St. Francis furnace was in blast, over fifty per cent. of the iron produced was white and mottled. Though it is generally stated that the wrought-iron made from bog ores is cold-short, such is not always the case, and bar iron produced in an old-fashioned *hearth-finery* was seen at the St. Maurice Forges which was not all cold-short, and which, on analysis, shewed only traces of phosphorus.

White and mottled irons.

Wrought-iron from bog ores not always cold-short.

The only localities in which I have had an opportunity of seeing deposits of bog ore are in the Seigniory of Vaudreuil and in the vicinity of the St. Maurice Forges. In Vaudreuil the ores are of very variable charac-

Localities visited.

* See Geol. of Can., 1863, p. 683.

ter; in Côte St. Charles the ordinary yellowish or reddish-brown concretionary variety is found, and sometimes forms ridges or lenticular patches with intervening hollows. The ridges appear to have been formed by the accumulation of the ore in what were once hollows or basins; the intervening sand was then washed away and a second set of basins formed in which ore has since been accumulating. In Ste. Angelique, on what is known as the McGillis property, and also in Ste. Elizabeth, a black or brownish-black concretionary ore containing a large proportion of oxide of manganese occurs. The concretions average probably not more than three-quarters of an inch in diameter, and are usually free from intermixed sand. A sample from the McGillis property, close to the brook, and a few hundred yards above the site of the old mill, was selected for analysis, and gave the following results:

Analysis of ore from Ste. Angelique, Vaudreuil.

Peroxide of iron	40.96
Oxide of manganese	26.34
Lime	1.48
Magnesia	traces.
Phosphoric acid	0.60
Sulphuric acid	traces.
Insoluble matter and soluble silica	12.08
Water and organic matter	17.97
	99.43
Metallic iron	28.67

When treated with hydrochloric acid chlorine is evolved and a considerable quantity of silica separates in the gelatinous condition; the latter is probably combined with protoxide of iron, the amount of which could not readily be determined, as the chlorine given off at once converts it into peroxide. The manganese in the above analysis is calculated as protoxide, although a portion of it at least must be present in a higher state of oxidation, judging from the evolution of chlorine. The ore of similar character in Ste. Elizabeth could probably be obtained in considerable quantity, and although not rich in iron would be valuable for mixing with other ores, on account of the large proportion of manganese which it contains.

Ste. Elizabeth.

In the vicinity of the St. Maurice Forges several varieties of bog ore also occur, but nothing was observed exactly corresponding to the highly manganesian ore of Vaudreuil. When at the L'Islet Forge a specimen was selected from a pile which had been taken from a bed two feet thick and underlying three feet of peat. The results of an analysis shew it to be an exceedingly pure ore. It contained,

Analysis of ore from L'Islet.

Peroxide of iron	69.64
Protoxide of iron	7.25
Protoxide of manganese	0.05

Alumina	0 90
Lime	0.53
Magnesia	traces.
Phosphoric acid	traces.
Sulphuric acid	0.05
Silica	1.93
Water and organic matter	22.04
	102.39
Metallic iron	54.36

The ore was partly compact, partly ochreous, and of a dark brown colour. It was examined for phosphorus by both the molybdate of ammonia and tartaric acid processes, but in neither case could more than traces be detected.

For the sake of comparison Dr. Hunt's analyses of bog ores, published in the Geology of Canada, page 511, are repeated here in the following table. The iron is given as peroxide, although Dr. Hunt states that in some cases it was present in part as protoxide.

Dr. Hunt's analyses of bog ores.

ANALYSES OF BOG ORES.

By Dr. T. Sterry Hunt.

Constituents.	I.	IIa.	IIb.	III.	IV.	V.	VI.	VII.
Peroxyd of iron	74.50	76.95	....	57.15	77.80	77.60	74.30	64.80
Sesquioxyd of manganese	....	....	....	....	....	0.30	traces.	5.50
Alumina	0.30	0.80	....	1.60	....	....	....	....
Silica	7.10	1.50	5.43	21.60	1.76	5.40	3.60	4.80
Phosphoric acid	....	....	1.52	....	0.61	1.81	1.80	undet.
Volatile matters	18.95	19.80	19.70	18.85	16.50	17.25	22.20	23.65
	100.85	99.05	....	99.20	96.67	102.36	101.90	98.75
Metallic iron	52.15	53.86	....	54.46	40.00	54.32	52.01	45.36

I.—From Petite Côte, Vaudreuil.
II. a. and b.—From Côte St. Charles, Vaudreuil.
III.—From Upper Rocky Point, Eardley.
IV.—From Bastard, twentieth lot, second concession.
V., VI. and VII.—St. Maurice Forges.

SPATHIC IRON ORE.

This ore, which is composed of crystalline carbonate of iron, may be regarded as the least important of all the iron ores of the Dominion, only one deposit being known which gives any prospect of being of economic value. In New Brunswick it is found in rocks referred by Professor Bailey and Mr. Matthew to the Huronian, sometimes in the form of veins, the thickest of which, however, are only about four inches. Its occurrence in small quantity in rocks of the St. John group, as well as in slates of Devonian age, is also mentioned by the same writers (Report of Pro-

Age of spathic ores.

gress, 1872–73, p. 227.) The deposit alluded to above as probably of economic importance occurs near Sutherland's River, in Pictou County, Nova Scotia, and was described by Mr. Edward Hartley in the Report of Progress for 1866–69, page 441. It appears to be a bed, the rocks above and below being sandstones of the Millstone-grit formation. Since Mr. Hartley's visit, further explorations have been carried on by Mr. G. M. Dawson, from whose report the following is extracted:

Extract from a report by Mr. G. M. Dawson on the spathic ore of Sutherland's River, N.S.

"The surface of the country is very deeply and uniformly covered by drift-material, and explorations on the area have been attended with considerable difficulty, it having been necessary to sink and cross-cut in the enclosing rocks. The ore is very well exposed in the bank of a brook. At this point, and near the level of the brook, a shaft 14 ft. deep has been made, and the ore proven to that depth, and its general character more clearly defined. It is evidently somewhat nodular in structure, being softer and harder in some places, and its junction with the overlying and underlying rocks having an undulating character. At the brook level the bed has a thickness of 10 ft. 6 in. At the bottom of the shaft this has decreased to 6 ft. 6 in., and it is probable that the ore, as followed, will continue thinning and thickening alternately. The dip of the ore and surrounding rocks is about S. 25° E., at an angle of 60°, and underlying the main bed of ore about 4 ft. was a small ore bed 6 in. in thickness. A shaft was sunk both east and west of the brook exposure, and at distances from it of 941 and 215 ft. respectively. The measures have been cross-cut several feet north and south in each, but as yet without discovering the ore bed. Small strings and layers of carbonnate of iron contained in reddish clayey sandstone were passed through in both places, showing that the bed was not far off; and in the north level from the west shaft, when we were obliged to suspend operations, the prospects seemed very good."

Thickness of ore seen at Sutherland's River.

None of the openings were accessible at the time of my visit, so that the only place in which the bed could be seen was in the bank of the brook, where, as stated by Mr. Dawson, it has a thickness of between ten and eleven feet. Before its real extent and value can be determined further explorations will be necessary.

Dr. Dawson has called attention to the fact of its being at no great vertical distance from a bed of gypsum, and to its being somewhat similar in mode of occurrence to the non-fossiliferous sub-crystalline limestones which occur in some parts of the Lower Carboniferous series associated with the gypsum.*

The ore when it has not been weathered is highly crystalline and of a grey or brownish-grey colour. On exposure the protoxides of iron and

* Can. Nat. new ser. VII. 3, p. 132.

manganese pass to a higher state of oxidation and the ore assumes a much darker colour. Some of it is a good deal mixed with limestone, and much of the material which has been extracted from the largest opening east of the brook consists of a porous or cellular grey limestone with scattered crystals of carbonate of iron. This, though probably not rich enough in iron to be smelted as an ore, would make an exceedingly valuable flux.

Limestone containing crystals of spathic iron.

The following analyses shew the ore to be of exceedingly fine quality:

ANALYSES OF SPATHIC ORE FROM SUTHERLAND'S RIVER, N.S.

Constituents.	I.	II.	III.	IV.
Sesquioxide of iron	16.98	20.52	....	....
Carbonate of iron	65.61	57.40	88.48	88.59
Carbonate of Manganese	7.98	8.29	1.85	2.85
Carbonate of lime	2.67	4.02	2.34	1.53
Carbonate of magnesia	3.23	5.66	5.82	3.48
Silica	3.76	2.38	1.51	2.70*
Hygroscopic moisture	.76	1.43	....	....
Sulphur	none.	undet.	....	.55†
Phosphorus	.013	"	....	none.
Organic matter	traces.	none.	....	....
	101.003	99.70	100.00	99.70
Metallic iron	43.56	42.07	42.80	42.76

I. and II. were made by Mr. Gordon Broome in the laboratory of the Survey; the first specimen was from the outcrop on Sutherland's Brook, the second from a costeaning pit about 75 feet farther westward. (Report of Progress, 1866-69, p. 442.) III. is by Dr. Stevenson Macadam, of Edinburgh, and IV. by Dr. T. E. Thorpe, of the Andersonian University, Glasgow.

CLAY IRON-STONE.

This is a compact earthy ore varying in colour from light brown or grey to black, the different shades often depending upon the presence of organic or coaly matter, or upon the peroxidation of the iron when the ore has been exposed to atmospheric action. It consists of carbonate of iron mixed with clay and other impurities, and though not rich in iron has been the chief source of that metal in England.

Characters of clay iron-stone.

In Canada it is found in rocks of Devonian, Carboniferous, Jurassic, Cretaceous, and Tertiary age. The Devonian iron-stones occur in layers and nodules in the shales which are interstratified with the Gaspé sandstones. They will probably never be of much importance as a source of iron.

Age of clay iron-stones.

In Nova Scotia they occur in the Carboniferous shales of the Cape Breton, Pictou, and Cumberland coal-fields, though very little is really known of the thickness or quality of the deposits. Many years ago

Nova Scotia.

* Insoluble matter. † Sulphate of lime.

attempts were made to smelt the ore from beneath the main seam at the Albion mines, but were not attended with success.

New Brunswick.

Clay iron-stones also occur in the Carboniferous of New Brunswick, but whether they are widely distributed I cannot say. Judging from the return of borings published in Gesner's 3rd Report to the Legislature of New Brunswick in 1840, the quantity af the Salmon River coal-field must be very considerable, as no less than about one-sixth of the 402 feet 9 inches bored through consisted of clay iron-stone. Gesner, however, says nothing as to its quality.

Vancouver Island.

The coal-bearing rocks of Cretaceous age in Vancouver Island often contain iron-stones, though little is yet known as to the quantity. At the Bayne's Sound Mines the nodules are of large size; some of them being flat or lenticular, and others round; the former vary in length from six inches to four or five feet, and in thickness from six to eighteen inches, and the latter are often as much as eighteen inches in diameter. (Report of Progress, 1872–73, p. 43). Mr. Richardson thinks that at this locality sufficient could be obtained for the supply of a blast-furnace. East of the Rocky Mountains Cretaceous iron-stones again occur, but little can be said as to the quantity until further explorations have been made.

Queen Charlotte Islands.

The Jurassic ironstones are found on the Queen Charlotte Islands in the shales associated with the anthracite. They are not known to be of economic importance.

Tertiary ironstones.

Those of Tertiary age occur in the lignite-bearing strata west of Red River, in the vicinity of the 49th parallel, where they have been observed by Hector, Professor Bell, Mr. G. M. Dawson and others. From the recently published report of the last named gentleman I quote the following: "The ironstones of this formation, though occurring very frequently in the same sections, and in close proximity to the coals, have not been observed in any place to attain a considerable thickness. They generally run in nodular sheets of only a few inches thick, through the clays and argillaceous sands. Externally they weather to various shades of chocolate-brown and reddish-brown, but are hard and compact in structure and within preserve their original bluish or yellowish-grey colour. They ring beneath the hammer, and break off in conchoidal chips. Considerable quantities of this material might be gathered from the surface in some localities, and it is probable that further search might bring to light localities in which so many layers of ironstone occur in the same section as to render it profitable to work over the entire bank. Should these ores ever come to be worked, limestone for use as a flux could be obtained in considerable quantities from the boulders of Silurian age which strew the plains in many places." *

* Report on the Tertiary Lignite Formation in the Vicinity of the Forty-ninth Parallel. By G. M. Dawson, Assoc. R. S. M.

But few of the Canadian iron-stones, so far as I am aware, have yet been analysed. The two following partial analyses of iron-stones of Tertiary age are given by Mr. G. M. Dawson (l. c., p. 30) :— Analyses by Mr. G. M. Dawson.

	I.	II.
Protoxide of iron	49.00	46.72
Water lost at 115° C	1.21	3.57
Carbonic acid lost on ignition	28.57	21.23
Siliceous matter insol. in H Cl	17.04	8.72
Sulphuric acid	0.26	0.30
Phosphorus	trace.	0.03
Metallic iron in raw ore	38.11	37.53
Metallic iron in calcined ore	54.27	49.90

A small quantity of the iron was in the state of peroxide, but was not estimated. No. I. is from Souris Valley and No. II. from 245-mile Valley.

The following is an analysis which I have recently made of a specimen of Tertiary iron-stone brought by Professor Bell from the "Dirt Hills" last summer. The ore is very tough and breaks with a conchoidal fracture, the freshly fractured surfaces being of a brownish-grey colour:— Analysis of ore from the Dirt Hills.

Protoxide of iron	51.977
Peroxide of iron	1.456
Protoxide of manganese	1.179
Alumina	2.306
Lime	1.140
Magnesia	0.650
Silica	7.026
Carbonic acid	31.850
Phosphoric acid	0.200
Sulphuric acid	0.053
Bisulphide of iron	0.088
Water { hygroscopic	0·846
Water { combined	0.534
Organic matter	0.524
	99.829
Metallic iron	41.486
Phosphorus	0.087
Sulphur	0.068

It will be noticed that the largest part of the sulphur is present in combination with iron, which is generally the case in iron-stones. Mr. Dawson, however, states that in the specimens examined by him the sulphur was present "entirely as sulphuric acid and in combination with lime." State of combination of sulphur.

Assays of iron-stones.

In the following table are given the percentages of metallic iron in eight samples of clay iron-stone from different localities:—

Locality.	*P.C. of Iron.*	*Age.*
1.—Pictou County, N.S., north of New Glasgow conglomerate.	30.55	Carboniferous.
2.—Barrasois, Cape Breton..........	27.84	"
3.—Baynes' Sound mines, V.I.......	36.83	Cretaceous.
4.— " " " "	29.78	"
5.—Scissors Creek, about 30 miles west of Fort Ellice..................	23.72	Tertiary.
6.—Second Hill, Woody Mountains	39.46	"
7.—First Hill, " "	41.05	"
8.—345-Mile Valley.....................	37.95	"

Specimen No. 1 was a nodule collected by Dr. Dawson. On breaking it open it was found to contain zinc blende, a mineral otherwise unknown in the Carboniferous of Nova Scotia.*

No. 2, collected by Mr. Charles Robb.

Nos. 3 and 4, collected by Mr. Richardson and assayed by Mr. Hoffmann.

Nos. 5, 6, and 7, collected by Professor Bell.

No. 8, collected and assayed by Mr. G. M. Dawson.

The average percentage of iron is 33.40.

ECONOMIC CONSIDERATIONS.

Under this head a few notes will now be given on the cost of labour, cost of mining iron ores, cost of shipment, of smelting, and other kindred subjects.

Cost of Labour.—The prices paid for labour in connection with the iron mines vary somewhat in different parts of the country. In general miners get from $1.25 to $1.40 per day, although the price sometimes runs below the former or above the latter figures. This will be best illustrated by a few examples from mines which were being worked in the past summer: At the Haycock location in Templeton and Hull, the average price paid for labour was about $1.30 per day. At the Bristol mine (Bristol, lot twenty-one, range two) the miners received $1.50 per day, this high price possibly being due to the demand for labour in connection with the Arnprior lumber mills. At the Dalhousie mine $1.25 was paid when the men boarded themselves, but only 80 to 90 cents when board was supplied. At the Blairton mines (Belmont) 150 men were being employed, receiving from $1.20 to $1.30 per day, according to the special kind of work in which they were engaged. They were furnished with cottages at the rate of $1.50 per month. At the Chaffey and Yankee

Examples of the cost of labour.

* Since the above was written Mr. Hoffmann has detected blende in a specimen of coal from Cape Breton.

mines in South Crosby the men were being paid by the month, getting from $20.00 to $26.00 besides their board. This, allowing 26 working days to the month, would be at the rate of from 77 cents to $1.00 per day, besides board. The men employed in connection with the St. Francis (Rivière aux Vaches) furnace and charring ovens, received last year an average of $1.25 per day, without board. About the same price was also paid to the men engaged in collecting ore. At the St. Maurice Forges wages were very low, an ordinary labourer getting in some cases as low as 70 cents a day and boarding himself. The men engaged in collecting bog-ore were being paid 30 cents for every *barrique** of ore taken out. The furnace-keeper and charger received $28.00 per month and the other men employed in connection with the the furnace $22.00.

At the Acadia mines, Londonderry, ordinary labourers received from $1.00 to $1.30, and miners $1.50 per day. The latter, however, were generally paid by the ton of ore extracted, and were making from $40.00 to $45.00 a month. The men employed in connection with the furnace were paid by the ton of pig iron produced, the keeper getting 25 cents and the others 20 cents per ton. This allowing the furnace to produce about 7½ tons per day would be $1.83 per day for the keeper and $1.47 for those under him.

In British Columbia no iron mines are, I believe, being worked ; the prices paid coal miners at the mines on Vancouver Island, however, ranged in 1872 from $3.00 to $4.00 per day. Ordinary labourers received from $1.75 to $2.00.†

Cost of labour in Sweden.

In the Swedish iron mines the miners get about 80 cents a day, or about half a dollar less than our iron miners on the Atlantic side of the continent.

Cost of Mining.—The cost of mining (getting and bringing to bank) a ton of ore of course depends upon the character of the ore and the enclosing rock, the position of the mine, depth of the workings, necessity of pumping or otherwise, cost of labour, and numerous other contingencies. In prospectuses it is often put down at 75 cents, but it would be difficult, if not impossible, to find a single instance in the whole country where ore requiring blasting is being mined for less than $1.00 per ton, even under the most favourable circumstances. There is, however, no doubt that in many cases the cost might be materially reduced by careful management and the use of steam drills and (with proper precautions) of such explosives as dynamite and dualin. At present many of the miners are inexperienced, and in drilling holes for blasting seem to be quite

Reduction in the cost of mining.

* 6 bushels, French measure. The *barrique* of ore weighs from 600-800 lbs., according to the quality of the ore.

† Report of the Hon. H. L. Langevin, C.B., Minister of Public Works, (Ottawa, 1872) p. 13.

unconscious of such a thing as *a line of least resistance.* By placing the hole in a wrong position a large proportion of the useful effect of the shot is lost and unnecessary expense involved. In nearly all cases the ore is obtained from open cuttings, there being only two or three iron mines in the whole country where underground mining is or has been carried on.

Underground workings.

Underground workings would, however, in many cases be advantageous, especially where operations are carried on during the winter, in which season, owing to the cold, snow, and ice, the cost of mining has in some

Examples of the cost of mining.

instances been nearly double the cost in summer. A few examples of the cost of mining in different localities may be of interest. At the Haycock location the ore delivered at the end of the tramway on the bank of the Gatineau River costs $1.76 per ton. The length of the tramway is 6½ miles. At the Dalhousie mine the cost of mining for the year ending February, 1871, was $1.25 per ton, not including outlay for plant, and including outlay for plant $1.46. From that date up to February, 1873, the cost was but slightly increased. A portion of the workings are underground. Quite recently operations at this mine have been suspended. At the Yankee and Chaffey mines in South Crosby the cost is only $1.00 per ton, but the conditions for mining are very favourable. The Chaffey mine, which is situated on an island in Mud Lake, on the Rideau Canal, is so close to the water's edge that the ore is raised by means of a crane and *dumped* directly into the barges. At the Blairton mine (Belmont) the ore costs $1.25 loaded on the cars which take it to Rice Lake. Much of it is raised from a depth of about 120 feet by an engine of 20 horse-power. Percussion steam drills are employed, the holes drilled being from two to three inches in diameter. A twelve horse-power engine is used for pumping the water which accumulates in the main opening. At the Acadia iron mines, most of the ore (limonite) which has been smelted for some years has been obtained from the Martin's Brook workings about 2½ miles from the furnace. The vein is here of somewhat irregular character, thickening and thinning alternately and often containing "horses." A good deal of "dead work" has accordingly to be done, increasing the cost of winning the ore. Exclusive of dead work the ores cost about $1.00 per ton at the mouth of the level, while if the dead work is included it increases the cost to from $1.90 to $2.00 per ton, Delivered at the furnace the ore costs $2.50 per ton. In the vicinity of the St. Maurice Forges the bog ore costs 30 cents a *barrique* or from 81 cents to $1.12 per ton. It has, however, to be drawn from 4 to 9 miles, so that the cost at the furnace is more than double the latter figure.

Cost of mining in Sweden.

In Sweden the mining of the magnetic ores costs from 55 cents up to $3.00, but the ore has often to be raised from depths of several hundred yards.

COST OF TRANSPORTATION.—Most of the ores which are mined in Canada are shipped to the United States to be smelted there. The mines, however, are often situated at considerable distances from railway or water communication, to which the ores have to be drawn by horses. The drawing is generally done in winter, since at that season the farmers are much of the time unoccupied and glad to obtain employment, and because much larger loads can be taken on sleds than on waggons. The prices paid for hauling ore of course vary much in different regions. Probably the smallest remuneration given anywhere has been at the Dalhousie mine, from which to Perth, a distance of 12 miles, the ore was drawn, by contract, during the winter of 1872–73 at the rate of $1.00 per ton. From Perth to the point of shipment on the Rideau Canal, 7 miles, the price paid was 60 cents. For the whole distance of 19 miles, then, the cost for carriage was only $1.60 per ton, or a little less than 8½ cents per mile. "The average weight of loads of ore hauled from the Dalhousie mine, by contract, to Perth in 1870–71 was 4 tons—3.99; in 1871–72 it was 4¼ tons—4.248; in 1872–73 it was 3¾ tons—3.74. The ton of 2240 lbs. is always used. The loads vary from 6,000 to 12,000 lbs., and sometimes run up to 14,000 lbs."* It must be borne in mind that most of the road is horizontal or in places down-hill. Were it up-hill, such large loads could not be carried. During the winter of 1872–73 ore was hauled from the Howse and Chaffey mines in Bedford to Westport on the Rideau Canal, a distance of 17 miles, for $2.40 per ton, or at the rate of 14 cents a mile. The road here is more hilly than that from the Dalhousie mine. At the same time ore was drawn from the Hull mines to the River Gatineau, a distance of about 2 miles, for 30 cents per ton, or 15 cents per mile. The road is horizontal or down-hill all the way, and as much as 5 or 6 tons were sometimes taken in a single load. At the Acadia iron mines, where most of the ore is drawn about 2 miles, the price per ton is from 50 to 60 cents, or 25 to 30 cents per mile; from the Cumberland Brook workings, a distance of about three miles, it is 85 cents. The amount hauled from the Martin's Brook workings to the furnace in a day by a pair of horses is only about 5½ tons.

Examples of the cost of transportation.

The ore of the Hull mines is chiefly shipped to Cleveland and by way of the Rideau Canal. The cost of shipment is said to have been only $2.50 per ton in 1872, but must be much higher now—probably $3.00–$3.50. From the Chaffey and Yankee mines, the ore is carried in barges to Kingston, a distance of 44 miles, for $1.00. From Kingston to Cleveland the cost for these as well as for other ores is $1.25 to $1.50. The Dalhousie ore is carried from the point of shipment on the Rideau to Kingston, about 60 miles, for from $1.25 to $1.50 (including loading).

* Information kindly sent me by Mr. Gerald C. Brown, Manager of the Dalhousie mine.

From the Blairton mine to Pittsburg the cost of transportation is said to be about $4.00.

Besides the ores which are carried to Cleveland, small quantities are sometimes shipped to Charlotte in New York state.

SMELTING OF IRON ORES.—The history of iron smelting in this country is neither a long one nor a brilliant one. The list of failures is greater than the list of successes ; but such is always likely to be the case, for a time at least, in countries like our own, where enterprises are too often undertaken by persons of little or no experience.

Number of blast furnaces erected.

No less than seventeen blast furnaces have been erected at different times in four provinces of what is now the Dominion, and in the following localities :

ONTARIO.	QUEBEC.	NEW BRUNSWICK.	NOVA SCOTIA.
Madoc.	St. Maurice Forges.	Woodstock.	Albion Mines.
Marmora.	L'Islet.	....	Londonderry.
Furnace Falls or Lyndhurst.	Batiscan.	....	Clementsport.
	Rivière aux Vaches.	....	Nictaux (2)
Normandale.	Bay St. Paul (2).	....	....
....	Hull.	....	....

PROVINCE OF ONTARIO.

Madoc.—The Madoc furnace was built in 1837, but was in blast only a short time when it was abandoned, one of the proprietors having been killed in the mine, and the other not having sufficient means to carry on the operations. The ore smelted was from the Seymour ore-bed in the eleventh lot of the fifth range of Madoc, and is said to have produced iron of very superior quality. For a short time wood was employed as fuel.

Wood as fuel.

Marmora.—The Marmora furnace is still standing, though in a dilapidated condition. It was erected before the one at Madoc. Several attempts have been made by different companies to smelt the ore of the big ore bed in it, but have been failures, owing, apparently, to distance from a port of shipment, inattention to the proper sorting of the ore and the nature of the required flux, and also to want of capital.*

Causes of failure.

Furnace Falls or Lyndhurst.—A blast furnace was erected here many years ago to smelt the red hematite occurring in the Potsdam rocks of the Township of Bastard, but the supply of ore was found to be inadequate, and the furnace was soou abandoned. Its ruins are still visible.

Normandale.—Many years ago a blast furnace was built here (near Lake Erie, 11 miles from Simcoe) to smelt the bog-ore of the township

* For fuller information concerning the Marmora and Madoc furnaces see "Report on Hastings" by Mr. Macfarlane, in Geol. of Can., 1866.

of Charlotteville. No information has been obtained concerning it, beyond what is stated in the Geology of Canada, 1863, page 683; but it has probably been abandoned.

PROVINCE OF QUEBEC.

St. Maurice Forges.—The St. Maurice furnace is situated near the River St. Maurice, eight miles distant from Three Rivers. It was built as early as 1737, and is interesting as a monument to the enterprise of the early settlers of the region, and from the fact that it is still in blast. The present proprietors are the Messrs. MacDougall of Three Rivers. Early enterprise.

The internal dimensions of this furnace are,

Height	30 feet.
Diameter at hearth	2½ "
" " boshes	7 "
" " throat	3½ "

There are two twyers, and the blast which is produced by water power is cold and has a pressure of about a pound to the square inch. At the time of my visit in October last the charge consisted of,

Bog ore	600 lbs.
Limestone	45 "
Charcoal	16 bushels (French).*

About 45 charges were made in the 24 hours, and the furnace tapped at intervals of from 12 to 18 hours. The daily production averaged 4 tons, of which 10 per cent. was white and 10 per cent. mottled iron. The charcoal is made chiefly from soft wood, and is burned both in heaps in the woods, and in charring ovens or kilns near the furnace. When charred in heaps 3½ cords † of wood are required to make 100 bushels of charcoal, but only two cords when the charring is performed in ovens. In the first case the volume of the charcoal would be only 34.32 per cent. of the volume of the wood, an unusually small yield, although the wood employed is of very inferior quality. The yield in the ovens equals 60.1 per cent. of the volume of the wood, an amount only a little below the average obtained in Sweden. The average weight of the charcoal is 11 to 12 lbs. to the bushel, and that prepared in heaps is considered better than that produced in ovens. About 180 bushels are required to make a ton of iron. The average cost is 6 cents per bushel. Yield of charcoal.

The ovens are built of ordinary red brick, and the dimensions of one of the largest are, Charring ovens.

Length	50 feet.
Width	14 "
Height to top of arch	19 "
Thickness of walls	1½ "

* The *minot*=2250 cub. in.

† The cord generally employed in the Province of Quebec contains only 108.375 cub. ft. The wood is cut three feet in length, and the piles are 8 ft. long and 4½ ft. high.

The ore smelted is entirely the bog ore of the region, and has now to be drawn for distances of from 4–9 miles, the supply in the immediate vicinity of the furnace having been to a great extent exhausted. In the furnace it yields from 33 to 35 per cent. of iron. The cost of the ore delivered at the furnace is about $2.50 per ton, or sometimes higher. The limestone (Trenton) has also to be carried several miles, and at the furnace costs 25 cents a *barrique* or 93 cents a ton.

Yield of ores.

Duration of blast.

The furnace is generally in blast for from 10 to 13 months at a time. Nearly all the iron produced is sent to Montreal and there manufactured into car wheels, although formerly it was made into castings on the spot. The pig was worth about $40.00 per ton in Montreal last summer. A small quantity of wrought iron is also made in an old-fashioned *hearth-finery** and used in the manufacture of axes of which 10 dozen are produced daily. These axes are said to have obtained quite a reputation among lumbermen, although it is only a short time since their manufacture was commenced, and orders are received far exceeding the production. The manufacture of cast iron stoves has been discontinued.

Manufacture of axes.

Analysis of St. Maurice iron by Dr. Hunt.

An analysis of a specimen of grey pig iron made at St. Maurice, in 1868, gave Dr. Hunt the following results:

Iron	undet.
Graphite	2.820
Carbon, combined	1.100
Sulphur	.025
Phosphorus	.450
Silica	.860
Manganese	1.240

Attempt to smelt magnetic ore.

Attempts were made a short time since to smelt the magnetic ore of Leeds (see pp. 205 & 209.) in the St. Maurice furnace, but were unsuccessful. The failure, however, was no doubt due to the want of height and proper lines of the furnace, and perhaps also to the want of experience of the furnace keeper in the treatment of other than bog ores.

L'Islet.—The Messrs. McDougall are also the proprietors of another furnace at L'Islet, about four miles from the one just described. Details concerning it are unnecessary, as they would differ but slightly from those just given for the St. Maurice furnace.

Batiscan.—Of the Radnor furnace, at Batiscan, I have received no special details. It was in blast during the past summer and iron being shipped to Montreal.

Riviere aux Vaches.—The St. Francis furnace, near the Rivière aux Vaches, in Yamaska county, was completed in April, 1869. Quite recently

* See page 235.

it has been purchased by the Messrs. McDougall of Three Rivers from the St. Francis River Mining Company. The internal dimensions are, Dimensions of St. Francis furnace.

Height	30 feet.	
Boshes	7 "	2 in.
Hearth	6 "	by 2 feet 2 in.
Depth of hearth	1 "	8 in.

There are two twyers placed horizontally, the blast is cold, has a pressure of from one to two inches of mercury and is produced by water power, the wheel having a diameter of 24 feet. The charge which has been found to work best consisted of, Charge.

Bog ore	600 lbs.
Limestone	½ bu.
Charcoal	18 "

The ore has yielded on an average 36 per cent. of iron, of which from 3 tons 4 cwts. to 4 tons 2 cwts. were produced daily, over 50 per cent. consisting of white and mottled iron. The total production from the first blowing in, in April, 1869, up to June, 1873, was 5,520 tons of pig. This was sent to Montreal, the port of shipment being Yamaska on the Yamaska River, 8 miles from the furnace. The cost of hauling to Yamaska was $1.50 per ton of pig. The charcoal was made in ovens 50 feet long, 16 feet wide, and 12 feet high, and intended to hold 75 cords of wood. The wood was both hard and soft (about ⅓ of the former to ⅔ of the latter), consisting of maple, birch, hemlock, spruce, larch, pine, and balsam. Yield of ore. Total production.

A cord of wood, provided it was dry, gave from 50 to 60 bushels of charcoal weighing from 12 to 13 lbs. to the bushel. This would be equal to from 60.1 to 72.1 per cent. of the volume of the wood employed. According to Mr. Rieher, the late manager of the furnace, to whom I am indebted for most of these details, the soft wood looses less in volume by charring than the hard wood. From about the 20th of May till the 1st of December, 25 men were employed in collecting ore; and from December to March, 30 carters with 60 horses in drawing it to the furnace. From the first of December to the first of April, 50 wood-cutters were employed in cutting wood, and 6 carters with 6 horses in drawing it to the charring ovens. Besides the manager, 7 men were employed in connection with the furnace and 7 at the kilns. Charcoal. Number of men and horses employed.

Bay St. Paul.—Two blast furnaces were completed in November last by the "Canadian Titanic Iron Company" near Bay St. Paul, for the purpose of smelting the titanic iron ore of the region. They have been in blast during the winter, but, although good pig iron has been made, its production, as might have been expected, has not been attended with profit, on account of the large amount of charcoal consumed. Manufacture of iron from titanic iron ore.

The dimensions of the furnaces are,

Height	40 feet.
Diameter at hearth	4 "
" " boshes	14 "
" " throat	8 "

Each furnace has three twyers and is closed at the throat by the ordinary *cup and cone*, in order to obtain the waste gases for heating the blast. For the production of the latter there are two blowing engines of 30 horse-power each. The fuel has been exclusively charcoal, made partly from white birch (less than half), partly from different kinds of soft wood, and weighing about 16 lbs. to the bushel of 2,675 cubic inches. The wood is charred in kilns, and a cord (128 cub. feet) produces on an average about 50 of the above bushels of charcoal. From 190–237 bushels of charcoal were, under the most favourable circumstances, required to make a ton of pig iron, and towards the spring, when the ore and limestone had become wet or covered with ice, as much as 400 bushels were sometimes necessary. Limestone was employed as a flux, and was obtained in the vicinity. The pig iron produced was entirely white. Generally speaking only from 4 to 5 tons were made in 24 hours by one furnace, but occasionally as much as 6 tons.*

Amount of charcoal consumed.

Analyses of pig iron.

The following are two analyses of the pig iron by Riley :—

	I	II
Carbon	3.966	3.976
Silicium	0.086	0.081
Sulphur	0.030	0.048
Phosphorus	0.253	0.258
Iron	95 245	95.440
Chromium	0·689	0.436
Manganese	minute traces	minute traces
Titanium	?	?
	100.269	100.239

The considerable proportion of chromium is a point of interest.

With regard to the smelting of titanic iron ores, the question is not whether they can be smelted, for of this there is no doubt, but whether, with the large amount of fuel required, they can be smelted profitably. It is said that in Sweden, where titaniferous ores are smelted, as much as 45 cwt. of charcoal are in some cases required to produce a ton of pig iron, this being considerably more than double the amount necessary in smelting the magnetic ores. It is needless to say that with such a consumption of fuel iron could not be profitably made in this country. Though so much has been said by Mushet and others about the beneficial effect of titanium upon iron, the question appears to be one requiring further investigation.

Charcoal required in Sweden.

* For these facts I am indebted to Mr. McColquohar, the manager at Bay St. Paul

As these points are especially important in Canada on account of the numerous and extensive deposits of titanic ore which occur, I take the liberty of quoting from a letter bearing upon them which was kindly sent me, at my request,in February last by Dr. Percy, the highest authority on metallurgical subjects. Dr. Percy says, "Experience here (in England) has shewn that no advantage is derived from the presence of titanium in iron ores. Good iron may be made from such ores, not on account, but in spite, of the presence of titanium. The titanium is worthless stuff and causes increase of fuel, because it must be made to pass into the slag; and *this means loss of heat.*" Remarks by Dr. Percy.

If titanic iron ore is to be utilized by the ordinary processes of smelting it must be by mixing it with other ores, so as sufficiently to reduce the proportion of titanic acid and the consumption of fuel. So long, however, as other ores can be obtained in abundance the demand for the highly titaniferous ores cannot be great. In some cases the addition of titaniferous ore to the charge is said to prevent the cutting of the furnace. Mixing of titanic with other ores.

Hull.—Details concerning the Hull furnace were given by Dr. Hunt in the Report of Progress for 1866–69, and since 1868 the furnace has not been in blast. Though still standing, it would require a very considerable expenditure to put it into proper condition for smelting, as it was much injured by the forest fires which devastated the surrounding country several years ago. The dimensions as given by Dr. Hunt are, height 38 feet, boshes 10 feet 6 inches, and throat 4 feet 5 inches. At the time of Dr. Hunt's visit in August, 1868, no less than 170 bushels of hard-wood charcoal, weighing from 22 to 23 pounds to the bushel, were being used in making a ton of grey pig iron. Dimensions of Hull furnace.

Province of New Brunswick.

Woodstock.—As early as 1848 a blast furnace was erected at Woodstock to smelt the hematites of Jacksontown. It was kept in blast, at intervals, until 1862, when it passed into the hands of William E. Smith, Esq., of Sheffield, England. In 1863 it was again blown in and kept in blast, at intervals, for several years. The whole time during which the furnace was actually in blast was only about eight years. Mr. Smith also erected a small cupola furnace in 1866, which, however, was only used for about a year. The blast furnace, which is still standing and said to be in good condition, is (according to measurements published by Professor Bailey in 1864) 39 feet high and 9¾ feet in diameter at the boshes. When it was running a hot blast was most of the time employed, and was produced by steam power, the waste gas from the furnace being utilized for generating the steam as well as for heating the blast. A red sandstone from Gulquac on the Tobique River, Victoria county, is said to have proved an excellent History of Woodstock furnace. Dimensions.

material for hearths. Charcoal, made chiefly from maple, birch, and beech woods, was employed altogether as fuel, the charring being performed in brick ovens. Limestone for a flux was obtained from Beccaguimic, seven miles from the furnace. The following are the constituents of the charge, as given by Professor Baily in 1864:

Charge.

Ore	1350 lbs.
Limestone	70 "
Charcoal	20 bu.

The burden must subsequently have been reduced, as Professor Hind, writing in 1865, states that the charge then consisted of,

Ore	1180 lbs.
Limestone	50 "
Charcoal	20 bu.

According to the latter authority, 3.33 tons of ore and 126 bushels of charcoal were required to make a ton of pig iron. The charcoal at that time cost seven cents a bushel; allowing that it weighed 20 lbs to the bushel, the quantity by weight required to make a ton of iron was 22½ cwt. The daily production of pig iron from one furnace was about 6¼ tons. Much has been said about its fine quality and its suitability for the manufacture of armour and boiler plate, as well as for steel. The analyses of the ores which have been published, however, indicate such a large proportion of phosphoric acid, that the fine quality of the steel, at least, seems doubtful.

Quality of iron produced.

The above details are mostly from Professor Bailey's *Report on the Mines and Minerals of New Brunswick*, published in 1864, and Professor Hind's *Preliminary Report on the Geology of New Brunswick*, published in 1865

PROVINCE OF NOVA SCOTIA.

Albion Mines.—A furnace was many years ago built near the Albion mines in Pictou County, but was in blast only a short time when it was abandoned. Some of the ore smelted was from a fossiliferous portion of the great Lower Helderberg bed of hematite described on page 217, and is said to have produced iron which, on account of the phosphorus, no doubt, was "exceedingly hard." Some of this iron has since been manufactured into stamp-heads which were found to wear longer than those made from any other kind of iron.

Iron used for stamp-heads.

Londonderry.—The only blast furnace in Nova Scotia which has produced much iron is the one at Londonderry, which was completed in 1853, and has, at short intervals, been in blast ever since. During the three years previous to 1853 a small quantity of iron had been made in a Catalan forge, which was abandoned on the completion of the blast

Catalan forge at Londonderry

furnace. The latter is 35 feet high, 9 feet in diameter at the boshes, and $4\frac{1}{2}$ feet at the throat. The stack is built of fire-brick and cased with iron. The hearth is lined with a mixture of fire-clay and pounded quartz (1 part of the former to 2 of the latter), the mixture being pounded in behind an iron cylinder which is afterwards removed. This lining is found to be very durable. The blast is cold and produced by water-power, the wheel, which is an overshot one, being 20 feet in diameter and 5 feet wide. At the time of my visit in September, 1873, the charge consisted of,

Description of Londonderry furnace.

Charge.

Ore (Limonite)........................	550 lbs.
Flux (Ankerite)	90 "
Charcoal	19 bu.

The number of charges in 24 hours was 59 or 60. For the 9 days previous to the 11th of September the production of pig-iron was 70.75 tons, or 7.86 tons a day, an amount slightly above the average. The following figures were kindly given me by Mr. Romans, manager of the works, and represent the amounts of ore, fuel, and flux employed in the month of August, 1873, and the corresponding production of pig iron:

Production of iron.

Returns for August, 1873.

Ore (Limonite)................	421 tons 6 cwt. 1 qr. (421.3125 tons).
Flux (Ankerite)...............	68 " 15 " 2 " 24 lbs. (68.775 tons).
Charcoal	32,471 bushels.
Pig iron produced	221 tons or 7.13 tons per day.

The monthly production is often higher than this, but these figures were chosen as being a fair average. If the ankerite is not taken into consideration, the yield of the ore in the furnace, as calculated from the above figures, is 52.45 per cent. Allowing, however, that the ankerite gives about 10 per cent. of iron, the yield of the ore is reduced to 50.81 per cent., or, in round numbers, 2 tons of ore are required to make a ton of pig iron. The charcoal is made from maple, birch, and beech, and according to Mr. Romans the bushel weighs about 20 lbs. The amount required to make a ton of pig iron in August, 1873, was 146.93 bushels, or about $26\frac{1}{4}$ cwt. Occasionally, however, it has been as low as 135 bushels, and many years ago as much as 160 bushels are said to have been required. It is burned in heaps by the farmers in the vicinity, and costs, delivered at the furnace, $7\frac{1}{2}$ cents a bushel.*

Yield of the ore.

Charcoal.

On page 247 it was stated that at the St. Maurice iron works as much as 180 bushels of charcoal are required to make a ton of iron from the bog ores; but there the charcoal is of very inferior quality, weighing only 11 or 12 lbs. per bushel of 2,250 cubic inches; and if a comparison by

* The bushel I suppose to be the Imperial bushel of 2218.192 cubic inches, or the same as was in use, according to How, in 1861.

weight be made, it will be found that while over 26 cwt. are required at Londonderry only 18½ are used at St. Maurice.

Duration of blast. The Londonderry furnace is in blast only six or seven months at a time. It is run by night and day shifts, and tapped about once every six hours. Furnace-men. During the day six furnace-men are required, besides a blacksmith, during the night only four. They are paid by the ton of iron produced, getting from 20 to 25 cents.

Cost of iron. The cost of production of a ton of pig iron may be estimated as follows:

2 tons of ore @ $2.50	$5.00
⅓ ton of ankerite @ $1.10	.36
147 bushels of charcoal @ 7½ cents	11.02
Labour and manager's salary	2.80
General expenses	1.50
	$20.68

The $1.50 for general expenses is my own estimate, but is probably a fair one.

Forge. Close to the blast furnace there is a forge where a considerable quantity of wrought iron has been produced. The building is 180 feet long and 60 feet in width, and contains five puddling furnaces and one reheating Casting-house and steel works furnace, a 25-cwt. steam hammer, rolls, and other appliances. The casting house and steel works are situated about a quarter of a mile from the furnace, and are large and commodious buildings. The casting house contains two furnaces with the necessary accessories for the manufacture of castings, which have been chiefly car wheels. The building containing the steel works is 250 feet long and 40 wide, and contains a smelting furnace, a converting furnace, three reheating furnaces, two steam hammers and other appliances.

Production of iron since 1853. Since the completion of the blast furnace in 1853 over 30,000 tons of pig iron have been produced, and, according to Professor How, the production of pig iron from 1862 to 1867 was as follows:*

	Pig iron.	Bar iron.
1862	1150 tons	945 tons.
1863	1251 "	911 "
1864	1663 "	1198 "
1865	1784 "	1633 "
1866	2124 "	1093 "
1867	2068 "	421 "

Quality of iron. The quality of the iron is known to be excellent, and Fairbairn says:† "Several specimens of iron from these mines have been submitted to direct experiment, and the results prove its high powers of resistance to

* Mineralogy of Nova Scotia, 1868, p. 89.

† Iron manufacture, 3d. Ed., p. 35.

strain, ductility, and adaptation to all those processes by which the finest descriptions of iron and steel are manufactured."

The following analyses of Acadia pig-iron by Tookey were published by Dr. Percy in 1864: * Analyses by Tookey.

Carbon	3.50	3.27
Silicon	0.84	0.67
Sulphur	0.02	0.01
Phosphorus	0.19	0.28
Manganese	0.44	0.37
Iron	94.85	95.70
	99.84	100.30

The manganese contained a sensible amount of cobalt.

Clementsport.—At Clementsport, in Annapolis county, a blast furnace was erected as early as 1831, to smelt the magnetic ores (Devonian) of the vicinity. For the past thirty years, however, it has only now and then been in blast, and but for a few months at a time. Part of the ore smelted recently is from the "Potter mine," about two and a half miles from Clementsport. Both the furnace and the mine are owned by Dr. E. C. Drew and O. Underwood, Esq., of Boston, but were leased to the "Annapolis Iron Company," Clementsport, in August, for $1.50 for every ton of pig iron produced. The furnace was blown in in December last, and kept in blast for two months, during which time about 200 tons of pig iron were made. The mine and furnace are under the management of Col. David Larned, to whom I am indebted for the following details: Proprietors of mine and furnace.

The furnace is built of stone, and is 35 feet high, 4 feet in diameter at the hearth, 9½ feet at the boshes, and 7 feet at the throat. There are three twyers, and the blast, which is hot and has an average pressure of from 1¾ to 2 lbs. to the square inch, is produced by water power, the wheel—a breast-wheel—being 30 feet in diameter. The blowing cylinders, three in number, are of cast iron, 4 feet in diameter and 5 feet stroke of piston. The blast is heated by burning the waste gases from the furnace in a hot blast oven containing 17 siphon pipes through which the air is made to pass. The oven is on a level with the top of the furnace, and is built of brick and bound with iron. Description of furnace, &c.

The ore from the Potter mine is locally known as "grey magnetic." In the furnace it yields as high as 45 per cent. of pig iron. When used alone, it produces white iron of poor quality, but when mixed with an equal weight of Bloomfield bog ore, the quality is improved. The latter ore does not yield over 26 per cent. of metal. The limestone employed as flux is brought from St. John, New Brunswick. The fuel is entirely charcoal, and is made principally from white birch. About 130 bushels Ore, flux, and fuel.

* Percy's Metallurgy, p. 540.

(Winchester) are required to make a ton of grey pig iron from the mixture of equal weights of magnetic and bog ore. The charge consists of from 750 to 800 lbs. of ore, 120 lbs. of limestone, or sometimes less, and 16 bushels of charcoal. The number of charges in 24 hours, when the furnace is working well, varies from 40 to 52.

Charge.

The Potter mine.

The Potter mine, alluded to above, was first opened as early as 1824. It is simply an open cutting or trench on a bed of ore said to be about 30 inches thick. The trench is about a quarter of a mile long, and 16 feet wide, the greatest depth being 30 feet.

Nictaux.—Two furnaces were many years ago (one of them in 1856) built at Nictaux, 37 miles from Clementsport, to smelt the fossiliferous hematite of Nictaux River. They did not, however, remain long in blast, and the iron produced is said to have been of poor quality, no doubt on account of the phosphorus in the ores. According to Mr. Romans, of Londonderry, one of these furnaces was 35 feet high, 9 feet in diameter at the boshes, and 4½ feet at the throat. The other was 38 feet high and 9 feet in diameter at the boshes. They are now in ruins, having been partly torn down by the people in the neighbourhood in order to obtain the bricks.

Dimensions of Nictaux furnaces.

MANUFACTURE OF STEEL AT QUEBEC.—In the month of June last, I had an opportunity of visiting the steel works erected at Quebec for the purpose of manufacturing steel directly from the purified iron sands of the gulf. Since the death of Mr. Labreche Viger the works have passed into the hands of a new company, the president of which is Mr. Chinic, hardware merchant, of Quebec. The enterprise, so far as I could learn, has not been successful, and at the time of my visit nothing whatever was being done.

The furnace is a well constructed Siemens regenerating furnace, with five gas producers, and except in the construction of the hearth, which is perfectly flat, and in one or two other minor details, resembles the one employed by the Messrs. Cooper & Hewitt at Trenton New Jersey, in the manufacture of steel according to the Siemens-Martin process.

Process of making steel from iron sands.

In making steel,* the sand, which had been purified by Dr. La Rue's magnetic machine, was mixed with tar and charcoal powder in a box containing revolving knives or beaters, and the mixture then pressed into square blocks by means of a powerful hydraulic press. The blocks were then piled upon the furnace hearth and melted down to steel, which was finally tapped off into ingot moulds containing about 200 lbs.

The cause of failure I was not told, but difficulty was probably experienced in obtaining a regular and homogeneous product. In the event of

* Since writing the above I have seen Mr. Chinic, who states that further and rather more successful experiments have lately been made with the furnace, and ten or twelve tons of steel produced. A good deal of difficulty was experienced in pouring, and the ingots were frequently *honey-combed*, and after forging were liable to contain flaws. Not more than 500 lbs. of steel were produced at a melting, which required six hours.

this process being abandoned, the furnace could readily be adapted to the manufacture of steel according to the Siemens-Martin process.

GENERAL REMARKS.—From what has been said it is evident that exceedingly little has been, or is being, done in the way of iron smelting in Canada; nor is there any prospect of an immediate increase in this important industry, except in the Province of Nova Scotia. This is due to a variety of causes, and among them, in some instances, to scarcity of fuel, in others to difficulty and cost of transportation, or to cost of labour. Notwithstanding such drawbacks, however, there seems little doubt that, with proper management, iron might be profitably made in many localities.* Drawbacks.

The owners of iron mines, instead of smelting their ores on the spot, are more and more turning their attention to shipping them to the United States, as this has been found, in most instances, to yield a fair profit. During the past year they were worth from $6.00 to $9.00 a ton in Cleveland.† According to official returns published by the Customs Department at Ottawa, 15,232 tons of iron ore were shipped from the Dominion during the fiscal year ending June 30th, 1870. From that date to June 30th, 1871, the amount was 26,825 tons, or 11,593 tons more than in the preceding year. The next year there was a slight falling off, the amount shipped being 26,175 tons; but in the year ending June 30th, 1873, there was a large increase, no less than 47,200 tons having been shipped. In addition to this exportation of 47,200 tons, an amount which may be estimated at about 12,000 tons was raised, but not shipped, part of it being smelted in the country. The total production of iron ore in the year ending June 30th, 1873, was, therefore, in round numbers, about 60,000 tons,—a quantity exceedingly small, though far ahead of previous years. Nearly the whole of the ore shipped has been from four or five mines. Shipment of ores.

The production of the Blairton mine, Belmont, is now greater than that of any other in the country, and in the last fiscal year is said to have amounted to nearly 30,000 tons. In July last it was being shipped to Pittsburg at the rate of from 300 to 400 tons a day. Blairton mine.

The annual production of the Yankee and Chaffey mines together, for several years, has been between 7,000 and 8,000 tons. Were the demand Yankee and Chaffey mines.

* It is possible that peat, or the charcoal made from it, might in some cases be advantageously employed in the manufacture of iron in Canada. Peat charcoal is largely employed in some parts of Europe, and, it is said, with satisfactory results. It is, however, generally very friable, and therefore unfit for distant transportation, or to resist the pressure in a blast furnace. It is also liable to contain a very large proportion of ashes, the whole amount in the peat being concentrated in the charcoal. Thus, if we suppose a peat to contain 10 per cent. of ashes and to yield 30 per cent. of charcoal or coke, the latter will contain no less than 33⅓ per cent of ashes.

† The duty upon iron ores going into the United States is at present 20 per cent. *ad valorem*, and upon pig iron $6.30 (gold) per ton of 2,000 lbs.

for titaniferous ores greater, the production of these two mines could readily be increased.

Dalhousie mine.

From the Cowan, or Dalhousie mine, from 3,000 to 4,000 tons have been annually raised and shipped for several years. Owing, it is said, to the dullness of the market, work has recently been stopped at this mine, although the ore is one of the finest in the country.

Hull mines.

The production of the Hull mines for the year ending June, 1873, was about 15,000 tons, which has since been shipped. No more ore has been mined here since the above date, and it is stated that there is a prospect of the mines passing into the hands of an English company. According to a gentleman in Cleveland who is well acquainted with Canadian ores, that from Hull yields from 60 to 62 p. c. of iron in the furnace, and is valuable for mixing with Lake Superior ores.

Haycock mine.

Since the opening of the Haycock mine in the winter of 1872-73 about 5,000 tons of ore have been raised, but none shipped, the intention being to erect furnaces near the Gatineau River for smelting it. The point chosen for this purpose is 6¼ miles from the mines, with which it is connected by a well built 3-feet-gauge tramway. At the mines there is a 20-horse-power steam sawmill, a boarding house, manager's house, storehouse, and blacksmith's shop.

Bristol mine.

The Bristol mine (see pages 196 and 208) is owned by Messrs. Taylor and Burns of Pittsburg, U.S. It was first opened in January, 1873, and work continued with 8 or 9 men until September. The ore raised during that time amounts to about 4,000 tons, and still lies at the mine awaiting shipment. At the time of my visit in July, the largest opening which had been made was 35 feet long, 24 feet wide, and about 20 feet deep, and from it about 1,500 tons (estimated) of ore had been extracted.

Fournier mine.

At the Fournier mine in South Sherbrooke, several hundred tons of very fine ore were taken out during the winter of 1872-73, and work has since been continued, although the prospects did not appear promising in July last. The ore (magnetite) occurs in thin irregular veins or beds, and is associated chiefly with hornblende and white or green feldspar.

Mines in Bedford township.

At the Howse, Chaffey (18 Island Lake), and Christie's Lake mines in Bedford, the Seymour ore bed in Madoc, and a number of other localities in Ontario, a small amount of work has been done during the past year, more especially for the purpose of determining the extent of the deposits of ore; and from lot three, range five, of Grenville, Quebec, several hundred tons of ore are said to have been extracted and shipped to Cleveland, Ohio, for trial.

Grenville.

Acadia mines

In Nova Scotia, the Acadia mines have since 1839 produced between 60,000 and 70,000 tons of ore, which has been smelted at Londonderry. The mines and works have recently passed into the hands of a new com-

pany with a capital of £500,000 sterling, and operations will no doubt be carried on on a larger scale and more systematically than heretofore. The company is entitled the "Steel Company of Canada (Limited)," and the following are the names of the Directors.

C. W. Siemens, Esq., D.C.L., F.R.S., C.E., London *Chairman.* Charles Tennant, Esq., St. Rollox, Glasgow. Archibald S. Schaw, Esq., Glasgow. William Tennant, Esq., 9 Mincing Lane, London. Edward Budd, Esq., Copper Office, Bond Court, London. Graham Menzies, Esq., London. Archibald Orr Ewing, Esq., M.P. Glasgow. George Stephen, Esq., Montreal. Donald McInnes, Esq., Hamilton, Ontario.

According to the prospectus, the Company has acquired no less than "33,000 acres, or 51 square miles of freehold land, together with the mines thereunder, and the work and buildings thereon, and including a pre-emptive right at 40 cents an acre to about 15,000 acres of adjoining land, and a working license at a royalty of 10 cents per ton of coal over one square mile of area No. 42 in the Spring Hill Coal Field." The Company has also "acquired from Dr. Siemens, at a cost of £8,000, the right to use free of royalty, his patent processes for the production of iron and steel and their subsequent working into merchantable form."

Considering the extent of the ore deposits, the facility with which both charcoal and mineral coal may be obtained, the proximity of the Intercolonial Railway, and of a shipping port on the Bay of Fundy, there is every reason to believe that, with proper management, this enterprise will be attended with success.

It is to be hoped also that something will soon be done towards developing the valuable deposits of iron ore in Pictou County. Here the ores are abundant and of varied character, they are near to the Pictou coal-field, whence coal suitable for the manufacture of coke could be obtained from a number of mines now in active operation. Limestone suitable for a flux occurs abundantly in the valley of the East River, the Provincial Railway passes through the coal-fields and within a few miles of the ore deposits, and the harbour of Pictou affords an excellent port of shipment during six months of the year.

Pictou County, N.S.

NOTES ON THE CRETACEOUS FOSSILS

COLLECTED BY

MR. JAMES RICHARDSON

AT VANCOUVER AND THE ADJACENT ISLANDS.

BY J. F. WHITEAVES, F.G.S.

To A. R. C. SELWYN, ESQ., F.R.S., F.G.S.,
DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

DEAR SIR,—In compliance with your request to that effect, I have examined with some care the specimens collected by Mr. Richardson last summer, and beg to submit the following provisional report upon them.

Your obedient servant,
J. F. WHITEAVES.

Introduction. The present collection, though not so large as that made by Mr. Richardson from the same region in 1871, is nevertheless highly interesting. With very few exceptions, the fossils are in a bad state of preservation. They belong entirely to the mollusca proper, and the brachiopoda are altogether unrepresented. The bivalves are usually mere casts, and even when the shell is preserved, the characters of the hinge and of the interior cannot be ascertained. Most of the gasteropods are very imperfect at the aperture, and the few cephalopods are, for the most part, mere fragments. No better clue to the specific and even generic affinities of these fossils is generally attainable than such as their general appearance, surface markings, and relative thickness of test, will supply.

Mr. Richardson informs me that they were collected from two zones, those from the first six localities being from his* "Productive Coal Measures, or Division A," while the remainder, those from Gabriola Island, are from his "Lower Shale, or Division B." A few of the fossils from the last mentioned locality appear to have been "loose specimens," while others were obtained *in situ*, but in the absence of Mr. R. it is not possible to separate these.

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* Report of Progress for 1872-73, page 35.

FOSSILS FROM THE PRODUCTIVE COAL MEASURES, OR DIVISION A.

Locality No. 1. From North West Bay, Vancouver Island.

(Cephalopoda.)

Ammonites, species A.— A large somewhat flattened shell with rounded back, and plain wide ribs, which are often alternately simple and bifurcate. A single large specimen about 7 inches in diameter, very imperfect below, but less so above, and with some of the interior layers of the test preserved. **Fossils from various localities.**

Ammonites, species B.—Allied to the preceding, of which it may be a variety, but with a more ventricose shell, and with somewhat different sculpture. In this form some of the costæ are continued across the last whorl almost to the sutures, while an alternate and shorter series occupy their interstices. Occasionally, however, the main costæ bifurcate as in the preceding species. Also a large species, measuring about 6 inches across.

Ammonites, species C.—Fragments only of a much flatter shell than either of the preceding, with the ribs closer together and not so prominent.

Note.—From this locality there appear to be three species of Ammonite, of which two are tolerably well preserved. The material, however, is insufficient to enable one to form a very precise notion of their specific relations, as there are only two moderately complete examples and six fragments in the collection.

Nautilus, sp.—One portion of a cast of a large species, shewing the central siphuncle. Also a cast of a single chamber, possibly of the same kind, but with the siphuncle subcentral.

(Gasteropoda.)

Cast of a small spiral univalve, apparently with three whorls; genus not recognisable.

(Lamellibranchiata.)

Inoceramus, sp.—Shell tuberculated and with V-shaped raised sculpture. Abundant, but not perfect enough for critical comparison with nearly related forms. Judging from larger fragments, most of the specimens are very young shells.

Cucullæa, sp.—A large shell, with prominent umbones, and a thick test ornamented with fine radiating ribs. Probably new, but too fragmentary for accurate description. It may belong to Conrad's sub-genus Trigonoarca.

Axinæa Veatchii, Gabb. var.—Several specimens.

Trigonia, species A.—A narrow, much curved, very convex and strongly ribbed shell, the ribs subnodulous. Perhaps an extreme variety of Trigonia Evansana, Meek.

Trigonia, species B.—A large, subquadrate, depressed form, with distant, rounded tubercles.

Astarte cardinioides, nov. sp.—Two examples of a shell, apparently new to science, and for which the above name is proposed, occur among the specimens from this locality. Descriptions with figures of this and of other species which appear to be new, will be found at the end of this report.

Astarte Vancouverensis, nov. sp.—Occurs sparingly with the above.

Besides these there are burrows of a Teredo-like shell, in fossil wood, and casts of another species of bivalve.

Locality No. 2. Coast a little W. of N. W. Bay, Vancouver Island.

Axinæa Veatchii, Gabb.—The only species.

Locality No. 3. Nanaimo River, Vancouver Island, 10 miles up.

(Cephalopoda.)

Ammonites.—Fragment of a small, smooth species, with a sharp and unserrated keel.

(Gasteropoda.)

None.

(Lamellibranchiata.)

Inoceramus, sp.—A concentrically grooved shell, but very imperfect. Three examples.

Lucina Richardsonii, nov. sp.—One well preserved individual.

Locality No. 4. Nanaimo River, Vancouver Island, 2½ and 2¼ miles up.

(Cephalopoda.)

None.

(Gasteropoda.)

Sycodes (?) cypræoides? Gabb.—A single imperfect specimen of a shell, from this locality, is doubtfully referred to this species. The much better examples, from Protection Island, have exactly the shape and surface markings of S. cypræoides, but there are indications of plaits on the columella in the shells brought home by Mr. Richardson.

Actæonina (?) sp.—Very imperfect but with much the shape of A. pupoides, Gabb.

Cinulia inflata (?) Gabb.—A few specimens.

Natica, sp.—Only a fragment, shewing, however, the characters of nearly the whole of the body whorl. Umbilicus none; shell with a strong keel running from the bottom of the aperture round the base of the whorls. As the upper part of the volutions appears to be angulated also, the shell should probably be referred to the sub-genus Euspira.

Fasciolaria ? nodulosa, nov. sp.—Two individuals, but not very perfect examples.

Aporrhais, sp.—One specimen, in very bad condition, and quite unrecognisable. It seems to have one central digitation, and in that respect resembles A. angulata, Gabb.

There are also two or three other species of Gasteropoda, but these are too imperfect for even the generic name to be ascertained. In one only a portion of the pillar is visible, but that has strong folds, as in the Volutidæ, or Fasciolariadæ.

(*Lamellibranchiata.*)

Inoceramus,—Two species.

Axinœa —— ?—Resembles A. Veatchii, Gabb.,in outline and thickness of test, but has much finer ribs.

Mactra, sp.—Several. The outline of this shell is very like that of Mactra Warrenana, Meek and Hayden, and it closely resembles also the Mactra albaria of Conrad.

Lucina ? sp.—(Cast.)

Anatina ? sp.—(Do.)

Pholadomya, sp.—A bad, distorted cast.

Nucula, sp.—(Cast.)

Locality No. 5. *From Protection Island.*

(*Cephalopoda.*)

None.

(*Gasteropoda.*)

Sycodes (?) cypræoides (?) Gabb.—Three specimens. See the previous remarks on this species.

Cinulia obliqua ? Gabb.—Badly preserved.

Gyrodes expansa ? Gabb.—One or two specimens, which are doubtfully referred to this form.

Fasciolaria nodulosa, nov. sp.—A single badly preserved example.

Also three unrecognisable species, in a fragmentary condition.

(*Lamellibranchiata.*)

Inoceramus, *sp.*—With flattened, distant, concentric ribs, somewhat as in I. Whitneyi, Gabb.

Dosinia, perhaps *D. tenuis*, *Meek.*—A single individual, of which a figure is given.

Mactra (?) *sp.*—A species with strong concentric ribs, perhaps an extreme form of Cymbophora Ashburnerii, Gabb. The only specimen is very different from any of the other Mactridæ in the collection.

Two or three other forms, of which the genera cannot be ascertained.

Locality No. 6. *Below Dodd Narrows.*

(*Cephalopoda.*)

Baculites, *sp.*—Fragments only.

Ammonites, *sp.*—Portion of a single chamber.

(*Gasteropoda.*)

None.

(*Lamellibranchiata.*)

Conchocele cretacea, *nov. sp.*—A few specimens, tolerably well preserved. The most abundant shell from this locality.

Also a few unrecognisable fragments, one evidently of a species of Inoceramus.

FOSSILS FROM THE LOWER SHALE, OR DIVISION B.

From Gabriola Island. (*The only locality examined.*)

(*Cephalopoda.*)

None.

(*Gasteropoda.*)

Natica, *sp.*—A solitary example of an imperforate, but not angulated shell, of which only the body whorl is present.

Cinulia, *sp.*, perhaps *C. obliqua*, *Gabb.*—A single cast.

Also a small imperfect spiral species, of which the genus is not recognisable.

(*Lamellibranchiata.*)

Nucula (*Acila*) *truncata*, *Gabb.*—One good example of this interesting shell is among the Gabriola Island fossils. Several specimens of the same species were collected by Mr. Richardson, in 1872, from the W. side of

Hornby Island in beds which he refers to his "Middle Shale, or Division D."

Axinæa, sp.—One very imperfect shell, obviously belonging to this genus, but different from the two other species previously catalogued from other localities.

Mactra, sp.—Possibly the same as those from Division A., Locality No. 4.

Tellina Meekiana, nov. sp.—A single well preserved example.

Anatina Tryoniana ? Gabb.—The only specimen is too imperfect to enable a confident opinion to be formed as to the accuracy of this determination.

Pholadomya, sp.—Near P. Breweri.

Remarks on the probable age of the deposits.

As was stated at the commencement of this report, with the exception of the fossil plants, which have been described by Principal Dawson on a previous occasion, Mr. Richardson's 1873 collection consists exclusively of shells. Of these, Baculites among the Cephalopods, Cinulia among the Gasteropods, and Inoceramus among the Lamellibranchiate bivalves, are each strikingly characteristic Cretaceous genera.

On the other hand, in a small collection made by Mr. Richardson at Quatsino Sound, Vancouver Island, in 1871, there occur two species, at least, which have been regarded as Tertiary fossils. Mr. F. B. Meek, to whom some of these fossils were sent, refers one to the Conchocele disjuncta of Gabb, a Miocene species of California, and another to the Dolium petrosum of Conrad, which occurs also in the Eocene and Miocene deposits of Oregon. From this locality there are five species, all of which are badly preserved casts. One of these is a Natica, and the rest are spiral gasteropods whose generic positions are very uncertain.

In Mr. Richardson's 1873 collection the fossils are altogether Cretaceous. The Conchocele, for which a new specific name is proposed, is associated with fragments of Baculites and Ammonites; and the Nucula truncata, although belonging to the same sub-genus (Acila of H. and A. Adams) as the Tertiary Nucula Conradi of Meek, is not only very distinct from it, but is still more closely allied to the N. bivirgata of Fitton a fossil characteristic of the Gault of Europe.

The coal-bearing rocks of Vancouver and the adjacent islands, with their associated shales, &c., have been referred to the "Chico group" of American geologists, a formation which is considered to be synchronous with the Upper Cretaceous of Europe, as recently defined. There is little room to doubt that these views are essentially correct. The lithological characters of the Upper Cretaceous strata of the Pacific Coast and of those of Europe are widely different, and it is reasonable to suppose that the physical conditions under which they were respectively accumulated were as diverse. In the Cretaceous rocks of Vancouver or California it is difficult

to find exact parallels for the five divisions which are usually characteristic of the Upper Chalk Formation of Europe.

In the Vancouver region it is not unlikely that the beds referred by Mr. Richardson to his "divison A." may form the base of the Chico group. The specific relations of the larger portion of the most characteristic fossils in the present collection have not yet been ascertained with sufficient certainty to throw any light on this point. So far, not even a single species from the Vancouver region can be proved to be actually conspecific with an European fossil. Several shells, however, are common to the Chico group of California and to that of Vancouver and the adjacent islands. The series from the "Lower Shales" of Gabriola Island is too small and the individuals too imperfect to afford much help in the elucidation of the relations existing between the deposits above and below them. Cinulia obliqua of Gabb ranges from Mr. Richardson's Division A. up to his Division D., and Nucula truncata, Gabb, occurs both in the "Lower Shales" of Gabriola Island and in the "Middle Shales" of Hornby Island.

DESCRIPTIONS OF NEW SPECIES.

Characters of new species.

The following descriptions are, to a certain extent, provisional. As, in certain cases, the essential charaters of the genera cannot be definitely ascertained, owing to the unfavorable state of preservation of the fossils, some of the names may have to be modified or changed. At the same time as the species appear to be new, it has been thought better to describe and figure them, in the hope that better specimens may soon be obtained, which will enable more accurate and complete descriptions to be given.

Luçina Richardsonii, nov. sp.—Shell obliquely semi-orbicular, somewhat inflated, very inequilateral, nearly smooth, with faint concentric striations. Umbones prominent, nearly marginal, dorsal slope almost straight, and making a rounded angle with the posterior part of the shell, which is slightly subquadrate. Anterior portion of the test, beneath the beaks, obliquely rounded off towards the ventral margin and almost truncate.

The outline is somewhat like that of Loripes dubia, Gabb., but our shell is destitute of the concentric ribs of that species, its umbones are nearly terminal, and the test is much shorter anteriorly.

Locality.—Nanaimo River, Vancouver Island, ten miles up.

Collector.—Mr. James Richardson, to whom the species is dedicated.

Conchocele cretacea, nov. sp.—Shell elliptical, somewhat quadrangular, inflated, beaks terminal, anterior: front end shallowly concave, making an acute angle with the ventral margin; base broadly rounded; posterior extremity slightly convex, forming an angle at its junction with the dorsal

margin. Two keels extend, on each valve, from the beaks to the posterior end, each of which incloses an excavated space of which the interior is the smallest; the outer area thus circumscribed is broadly lenticular, while the inner one is rather shorter and much narrower. The outer dorsal ridges are somewhat convex, and the area inclosed is only slightly higher when the shell is viewed laterally. Surface ornamented with fine sub-equal concentric striæ. Conchocele disjuncta, Gabb, the only previously known species in this genus, is a larger, less oblique, and more trigonal shell, straightly truncated anteriorly, whereas C. cretacea is distinctly concave in that region. In our species the prominent keels are entirely dorsal, and are separated from the ventral margin by a considerable space, indeed by the whole siphonal end of the shell, whereas in C. disjuncta the ridges make a bold curve from the beads to the posterior dorsal margin.

The outline of this remarkable shell is so different from its nearest ally, that a new specific name has been proposed for it. It is possible that when larger series of specimens can be compared, our shell may prove to be only an immature state of the type species.

The marked differences between the two shells, however, as well as the circumstance that the C. disjuncta is described as a Miocene fossil, while the Vancouver Island shell is almost unquestionably Cretaceous, seem to justify their separation.

Astarte Cardinioides, nov. sp.—Shell ovately-elliptical or sub-quadrangular, very unequilateral, bluntly truncate both in front and behind, but much narrower behind; flattened or only very moderately convex. Umbones depressed, placed at about seven eighths of the length from the anterior end; hinge line sloping gradually downwards; an obtuse and barely perceptible angle runs from the beaks to the posterior ventral margin; posterior end sub-truncate; ventral margin very slightly convex; anterior extremity wider than the posterior, also subtruncate, but more produced towards the ventral margin. Test thick, with a crenulated inner margin: the surface ornamented with tolerably strong concentric costæ. Named from its close resemblance to some of the Liassic Cardiniæ.

Locality.—North West Bay, Vancouver Island.

Collector.—Mr. James Richardson.

Astarte Vancouverensis, nov. sp.—Shell oblong, very inequilateral, beaks almost terminal: very short in front, produced and somewhat pointedly rounded behind; test thick, margin crenulated. Surface with concentric costæ, much as in the preceding species.

Locality.—North West Bay, Vancouver Island. Also coast a little W. of North West Bay.

Collector.—Mr. James Richardson.

The interior characters of the two species just described cannot be

ascertained, but from the thickness of the test, the crenulated border, and surface markings, it is evident that they both belong to the Astartidæ. Their outline is not unlike some forms of Cypricardia, but the grooved ribs seem to place them in the typical genus Astarte. Only two or three specimens of each were obtained, and these appear to be water worn and are otherwise badly preserved. At first they were thought to be extreme forms of one variable species, but a more careful study of the specimens has led to a different conclusion.

Locality.—Below Dodd Narrows.

Collector. —Mr. James Richardson.

Tellina Meekiana, nov. sp.—Shell ovate, compressed, very inequilateral; beaks one-third of the length from the anterior end, not very prominent, pointing slightly forwards; hinge margin sloping down somewhat rapidly to the posterior end, which is narrowly rounded, much more so than is the opposite termination; base, elliptically convex. Test thin, ornamented with close, fine concentric striæ.

As none of the characters of the interior can be made out in the only specimen collected, it is by no means certain whether this shell belongs to the Tellinidæ or Veneridæ. Its outline is singularly like that of Meretrix lens, but the thinness of the test, the characters of the beaks, the sculpture, and flatness of the Gabriola Island shell, seem in favor of the view taken.

Locality.—Gabriola Island. From the Lower Shale, or Division B.

Collector.—Mr. James Richardson.

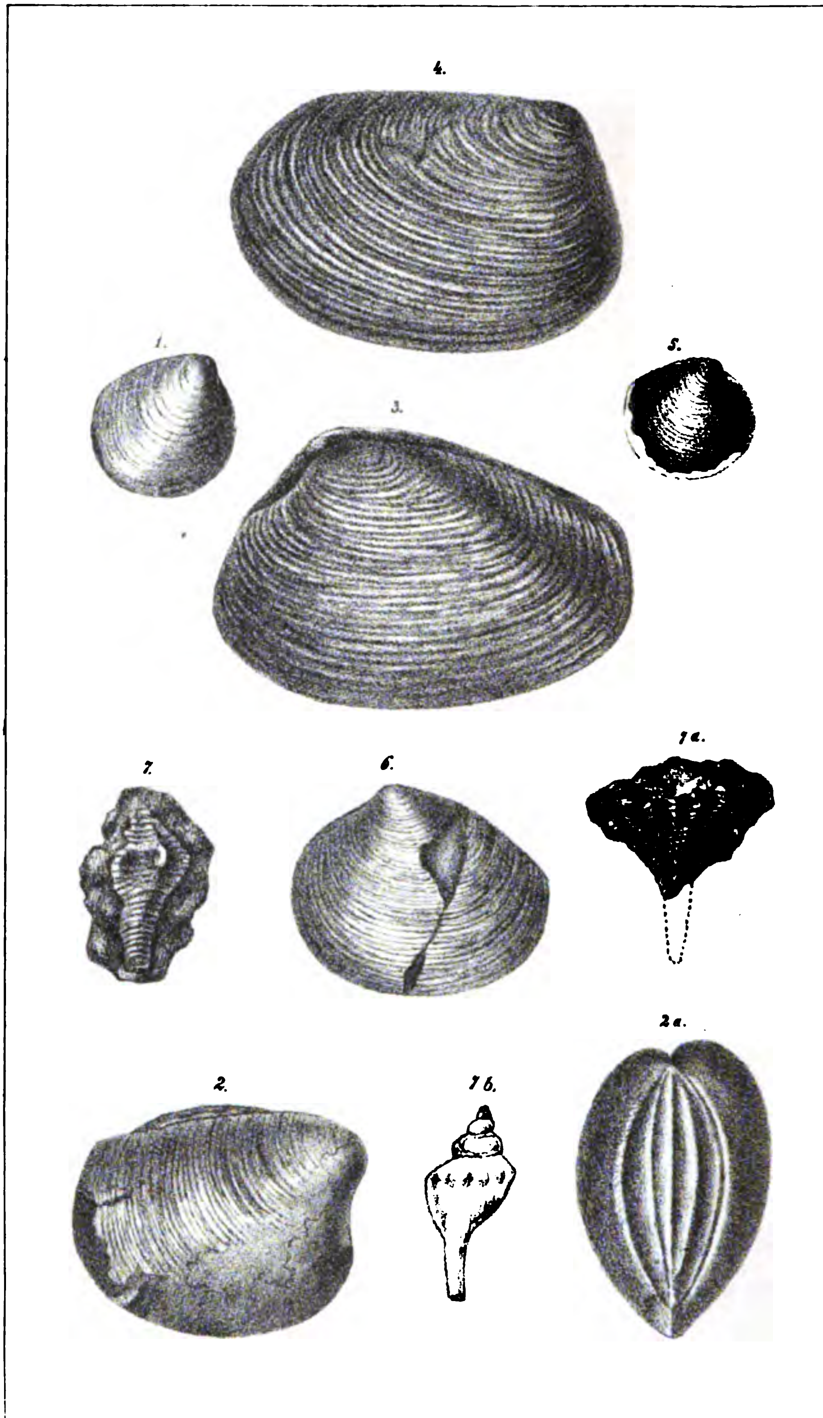
Fasciolaria nodulosa, nov. sp.—Shell angularly fusiform; spire pointed, rather short, about one-fourth of the entire length of the shell, or less; body whorl conspicuously angulated below the suture, somewhat ventricose; canal long and tapering, almost straight. The upper volutions are undulately ribbed, and the body whorl is ornamented with raised nodulous, distant tubercles, or elevations, at the angle below the suture; their interstices are widely excavated longitudinally. The whole surface is covered with sub-equal, somewhat flattened, strong, transverse revolving ribs, and the shell is also faintly striated longitudinally.

As the interior of the shell is not visible in any of the specimens collected, it is impossible to say whether there are any plaits on the pillar or not. It is provisionally placed in the genus Fasciolaria, on account of its close agreement in external characters with some recent species of this group, such as the F. fusiformis Lamarck, from Port Philip. It may prove to be a Fusus, and indeed it bears no very remote resemblance to F. Mexicanus of Gabb.; still, it differs from that shell in several important particulars.

Locality.—Nanaimo River, Vancouver Island, two and a quarter miles up; also Protection Island.

Collector.—Mr. James Richardson.

GEOLOGICAL SURVEY OF CANADA.



A.H. Foord, del et lith. Geo. Gebhardt, impt

CRETACEOUS FOSSILS from VANCOUVER
and ADJACENT ISLANDS.

EXPLANATION OF PLATE.

FIG.

1. Lucina Richardsonii.
2. Conchocele cretacea.
3. Astarte cardinioides.
4. " Vancouverensis.
5. Dosinia tenuis? Meek.
6. Tellina Meekiana.
7. and 7. *a* Fasciolaria nodulosa, view of two different individuals with the test shewing sculpture preserved.
7. *b* Outline of another specimen of the same species.